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628

FARMERS' BULLETINS
Nos. 1151-1175

WITH CONTENTS AND INDEX

PREPARED UNDER THE SUPERVISION OF
JOHN L. COBBS, JR.
CHIEF, DIVISION OF PUBLICATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

BINDING
JAN 17 '44

405722

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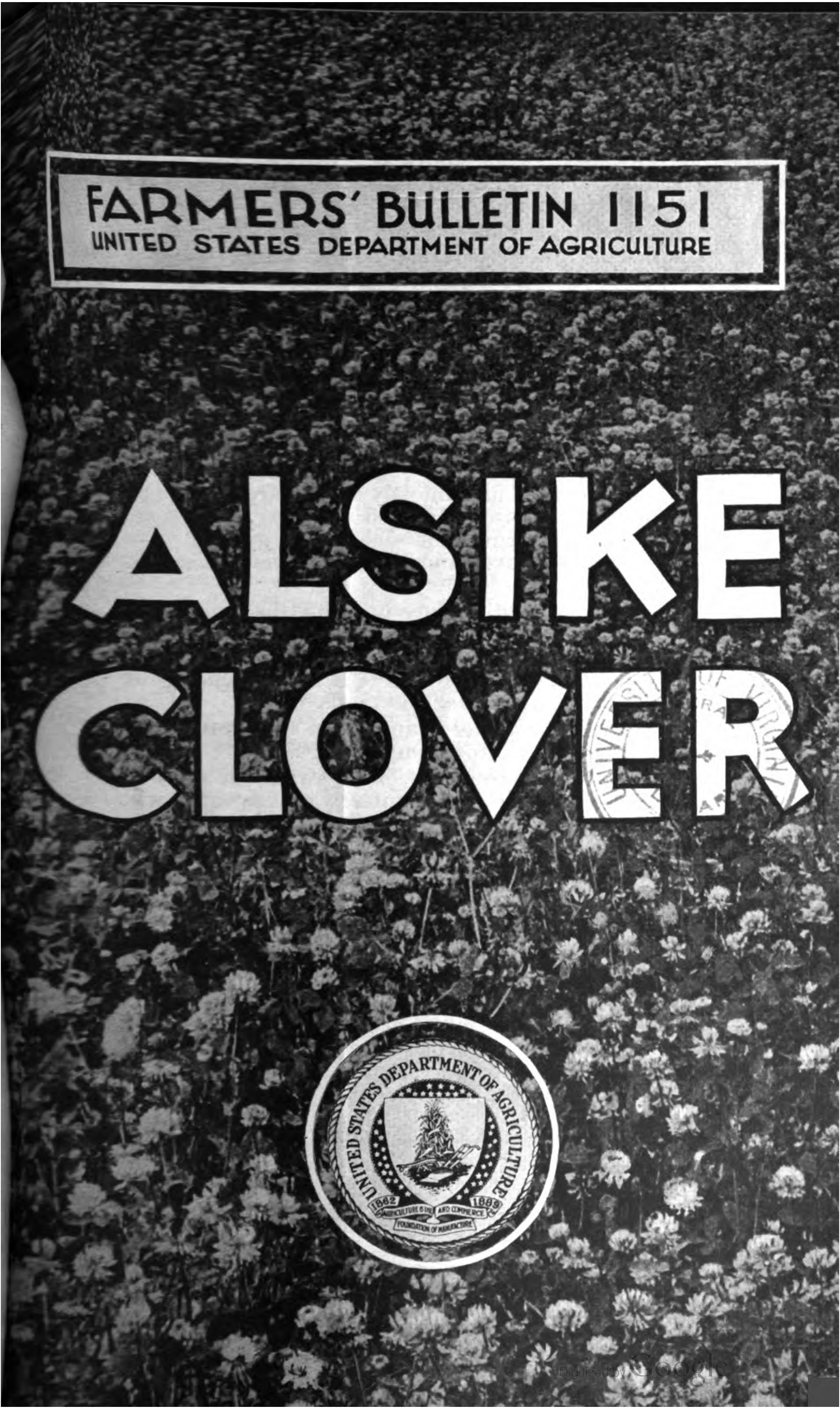

FARMERS' BULLETIN 1151

UNITED STATES DEPARTMENT OF AGRICULTURE

ALSIKE CLOVER

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ALSIKE CLOVER is most at home in northern latitudes or at high altitudes. It thrives best in a cool, moist climate.

In the Ohio Valley alsike clover is especially adapted to low, wet, fertile land. On such land it will yield heavy crops of first-class hay and will make more than one crop in a season.

This crop will grow on "sour" land on which red clover will not thrive. Where it is not possible to apply lime and so insure a stand of red clover, alsike clover may be used.

Mixed with red clover on uplands, alsike clover insures a stand on spots where red clover does not catch.

Alsike clover is used mostly in mixtures with timothy or other grasses. In such mixtures it improves the hay and increases the yield. The grasses serve to support the clover and make it easier to cut and cure.

Alsike clover will endure overflow that would kill most crops. It has been known to grow a year in water-soaked and water-covered soil and make a heavy growth. In the South it is recommended for creek bottoms and other wet lands.

It is a good pasture plant, often remaining in a permanent pasture for many years.

It is a good clover to seed in swales or on wet, natural meadows. It volunteers readily and will spread in such places.

Its disadvantages are that—

(1) On uplands alsike clover grows short and does not make a mass of growth equal to that of red clover.

(2) Alsike clover makes no second crop except on low, rich land.

(3) On uplands the pasturage after cutting for hay or a seed crop is too small to be useful.

(4) There appears to be some danger to horses and mules of a little-known disease said to result from eating alsike clover.

Contribution from the Bureau of Plant Industry.

Wm. A. Taylor, Chief.

Washington, D. C. September, 1920.

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ALSIKE CLOVER.

A. J. PIETERS, *Agronomist in Charge of Clover Investigations, Office of Forage-Crop Investigations.*

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UTILITY OF ALSIKE CLOVER.

CLOVER is a basic crop in the agriculture of the greater part of the Northeastern States and as far west as the Great Plains. In this region red clover is the standard leguminous rotation crop, but there are soils and situations in which red clover will not thrive. Low, wet land and soils that are low in lime content or have been run down by long and unwise cultivation are unsuited to red clover. On many of these soils alsike clover can well replace it. Alsike clover succeeds better than red clover on wet land, and when mixed with red clover on uplands it will insure against failure from lack of lime or other unfavorable soil condition. When red-clover seed is extremely high in price, alsike clover can be substituted on many soils. The seed is often cheaper, and being smaller than that of red clover less is required to the acre.

HISTORY OF ALSIKE CLOVER.

Alsike clover is a native of northern Europe and is known also as Swedish or hybrid clover. The names alsike and Swedish refer to the locality and to the country from which this plant was introduced into England, while the name "hybrid clover" was given it because it was thought to be a cross between red and white clovers. It was named *Trifolium hybridum* by Linnæus in 1753, as he too believed

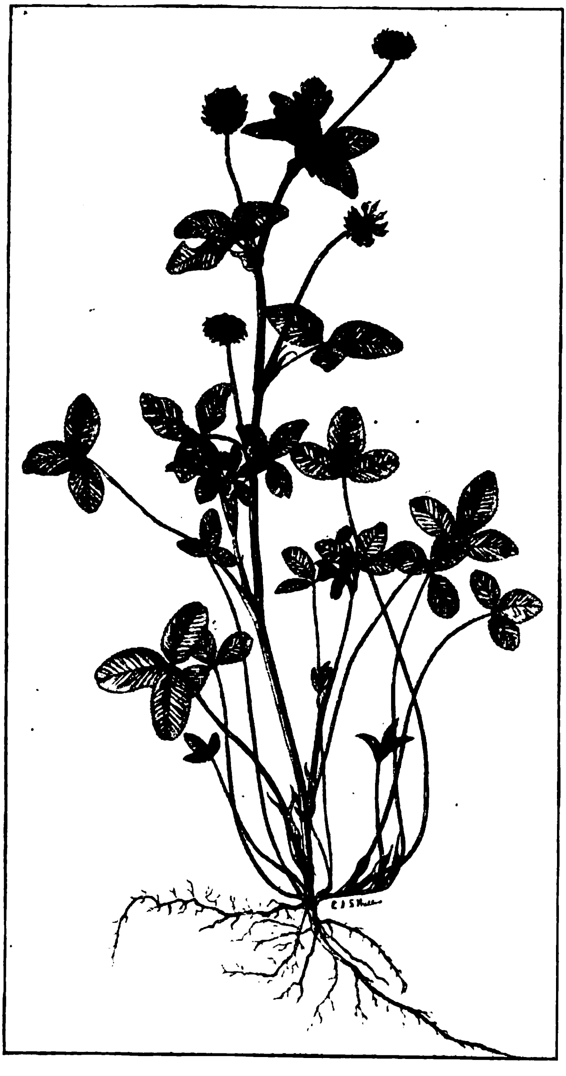

FIG. 1.—Alsike-clover plant, showing the habit of flowering; the oldest flower heads below, the youngest coming out above. The older flowers are reflexed; the younger ones erect.

in the hybrid origin of the species. In its native home it has been cultivated since early in the tenth century, but it was not until about 1834 that seed was brought to England, and five years later the editors of the New Genesee Farmer, of Rochester, N. Y., brought some seed to this country and distributed it to the readers of that paper. In 1854 a distribution was made by the United States Patent Office. Doubtless there were other importations. Emigrants from northern Europe came to this country, and some of them are known to have brought alsike-clover seed with them. An Austrian named Walenta, who settled in Winneshiek County, Iowa, in 1854, brought seed of alsike clover with him; probably other settlers did the same.

BOTANICAL CHARACTERS OF THE PLANT.

Alsike clover is perennial, though usually treated agriculturally as a biennial. Many smooth stalks come from the crown, and they bear smooth leaves, each with three leaflets, and heads of flowers partly pink and partly white. In many heads the flowers are all white; in others, all pink. As the flowers fade they bend back and hang down. (Fig. 1.) Under favorable conditions the stalks grow 3 to 5 feet long;

but on drier soil they may not become more than 18 inches in height. Alsike differs from red clover in its habit of growth. In red clover the main axis terminates in a flower and thus limits the growth. Branches arise from the leaf axils and these in turn are terminated by flowers. In alsike clover the main axis keeps on growing. Single flower-bearing branches, each with one or more flower heads, arise successively from each leaf axil. (Fig. 1.) The leafy branches may in turn keep on growing, with flower heads or smaller branches in the axil of each leaf. Thus, in red clover the terminal flower head of the main stem or of a branch is the oldest on the plant or branch, while in alsike clover the terminal flower heads are the last formed, the older ones being successively lower on the stem. While in red clover the flower heads are not borne at exactly the same height from the ground, there is no great difference between the levels to which the various flower heads rise. In alsike clover the stem, however long, may bear flower heads along its entire length. This character is important not only from the standpoint of seed production but in making alsike clover fit to cut for hay over a longer period than in the case of red clover.

CLIMATIC ADAPTATION AND DISTRIBUTION.

Alsike clover prefers a cool climate. Its home on the Scandinavian Peninsula shows that it is fitted to withstand cold weather, and this is confirmed by experience in this country. This clover withstands severe winters better than red clover, and it thrives best where the summers are cool. In the South it is less successful, thriving only where an abundance of moisture enables it to overcome the injurious effect of the warm summers. The geographical distribution of this clover in the United States is roughly that of the timothy-clover area. (Fig. 2.) Alsike clover is very generally grown in the area north of the Ohio and Potomac Rivers and as far west as the Dakota-Minnesota boundary. It also is grown in Idaho and on the Pacific coast of Washington and Oregon. In the South alsike clover is grown to a limited extent in Virginia, Kentucky, Tennessee, and Missouri, but in other Southern States it is almost unknown.

SOIL AND MOISTURE REQUIREMENTS.

Alsike clover prefers a rather heavy silt or clay soil with plenty of moisture. Although it will thrive on good loams, it usually does not do well on dry, sandy, or gravelly soils. A rich, moist bottom soil suits it best, and on such soils it will grow luxuriantly. It responds to an application of lime, but is not as sensitive to acidity as red clover, and can be successfully grown on many wet, cold, and "sour" soils on which red clover does not succeed.

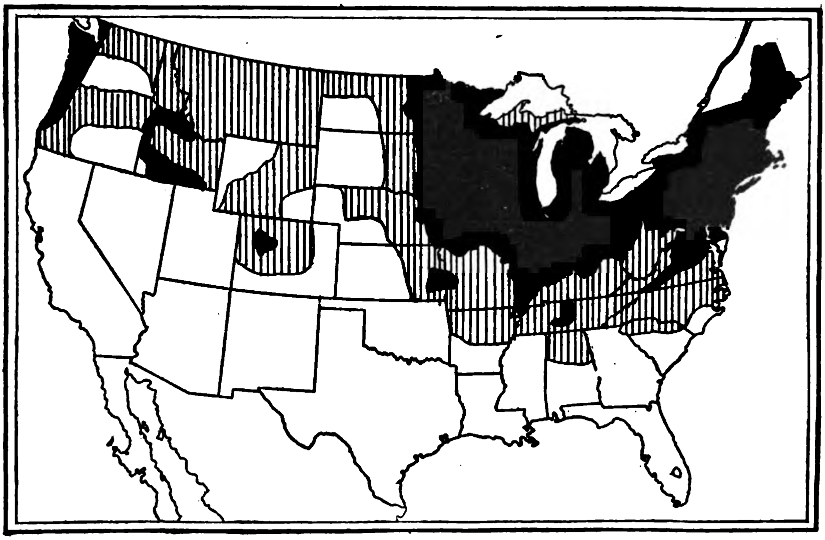

FIG. 2.—Outline map of the United States, showing roughly the area in which alsike clover is grown. The black area shows where alsike clover is more or less regularly used as a forage or seed crop; the hatched area, where it is rarely grown or only in special places.

SEED, SEEDING, AND COMPANION CROPS.

The seeds of alsike clover are small, there being 700,000 to the pound. This is more than twice as many as there are of red-clover seed in a pound. The color of the seed is green of various shades mixed with yellow. With age the color becomes darker, and very old seed may be brownish green. Seed of the last sort is not fit for planting.

In the Northern States the seed is usually sown in early spring, though in many places in late summer, for instance in New Jersey, where clover seeding often follows early potatoes or cabbage in July and August. In Indiana and Ohio seed is sometimes sown in corn at the last working, but there is always considerable risk connected with this, and the practice can not be recommended save in exceptional circumstances. Seeding in July with buckwheat is successfully practiced in southern Michigan, but this method is not general. If for any reason a stand is not secured from spring seeding, the stubble field may be disked and clover seeded in late July or August, with a fair chance of success unless a severe drought should occur. In those parts of the South where alsike clover is used it is commonly seeded in the fall.

When sown in spring the seed is either broadcasted on winter grain or it is sown with spring grain. Seeding on winter grain is usually done as it is with red clover, the seed being broadcasted when the ground is checked by frosts or else on a late snowfall, so that the seed may be carried into the ground with the thawing of the snow. When seeded with spring-sown grain the seed bed is in good shape and the clover can be most advantageously put in with a drill.

There being, as stated, some 700,000 seeds in a pound, every pound of seed if evenly scattered will put about 16 seeds on every square foot of an acre. If 6 pounds of seed are evenly scattered there will be one seed on every 1½ square inches. When 5 pounds of seed are drilled there will be an average of one seed every half an inch in the drill with the rows 4 inches apart. These quantities of seed will make heavy stands if not more than half the seeds finally produce plants. While thicker seeding may help to choke out weeds, it must not be forgotten that with too thick seeding a certain percentage of clover plants will also be smothered out and much seed will be wasted.

When broadcasted on winter grain, rather more seed should be used than when drilled, as much of it will be wasted. When the soil is dry enough it is good practice to harrow in the broadcasted seed. This may be done with a spring-tooth weeder or with a spike-tooth harrow having the teeth set back. Harrowing will rather benefit the grain and will make a stand of clover more certain. The use of a drill wherever possible is urged. It will save seed, and the seed being put into the ground at a proper and uniform depth the seedlings will have a better chance to grow and the stand will be better. Care should be taken not to seed to deeply. On heavy soil one-half inch and on light soil an inch is deep enough. On poor or on run-down soil care is especially important, and broadcasting the seed on such soil when checked by frost or on snow is too risky to be recommended; it should be drilled or harrowed in. For success a good seed bed is important. It should be firm, but fine on top, so that the young plants may be well supplied with moisture.

While the methods to be employed to get a good stand of alsike clover will differ with the locality and will depend on soil and climate, the principles involved are simple and can be briefly stated. To grow the seed needs warmth, air, and moisture, and to thrive the plants must have food, light, warmth, air, and moisture. Seed may be sown so early that the young seedlings which have started during some early warm days are killed by a late frost, but this does not happen often. A more frequent cause of the loss of a seeding is dry or hot weather after grain harvest. Before grain harvest the young clover plants have to compete with the grain for moisture, and the grain also shades the clover, which keeps it weak. While the grain tends to keep down the weeds and so serves a useful purpose, it also keeps down the clover, and when the grain crop is heavy the clover may easily be smothered out along with the weeds. When the season is dry, the grain gets the larger share of the moisture and the clover suffers in severe cases so badly that the young plants die. Loss from drought is naturally greater on sandy soils and on run-down soils, as neither of these contains much organic matter. Organic matter helps a soil to hold moisture, and soils with little organic matter tend to lose moisture rapidly. If clover, then, is seeded in spring on a run-down soil, on winter grain or with oats, the grain will get what moisture there is, and in a dry season the result may be the failure of the clover to make a stand. On rich or moist soils or in a wet season there will be moisture enough for both grain and clover.

It remains, then, for each farmer to decide for himself whether on a piece of run-down land he wants to get a crop of grain or one of clover. For the good of the land, of course, the clover should have first consideration, and the chances for the clover will be much better with a light than with a heavy grain crop. It may not be advisable to omit the companion grain crop entirely, but the seeding should be reduced, or a companion crop should be selected that is least hard on the clover. As a winter grain rye is usually better than wheat, since it does not shade the ground so much and comes off earlier. If oats are used, an early variety is better than a late one. Further, it is often better to sow 1 bushel of oats than to sow 2, and, lastly, if the season turns dry it is better to cut the grain in the dough stage for hay than to allow it to ripen for grain. Often if the oats are cut early for hay a light cutting of alsike-clover hay may be taken the same year. The object should always be to leave sufficient moisture for the young clover plants, especially at the critical time just after the removal of the companion crop.

Alsike clover is seldom seeded alone unless a seed crop is wanted. Usually it is seeded with timothy, with red clover, or with both. A common practice is to sow timothy in the fall and to sow alsike alone or alsike and red clover in the spring. Rather more seed of timothy and red clover than of alsike clover is then used, a common formula being alsike clover, 1 part; red clover, 1 to 2 parts; timothy, 2 to 3 parts. The same ratios usually obtain when alsike clover is seeded with timothy alone or with red clover alone, 8 to 12 pounds of such a mixture per acre being generally used.

INOCULATION.

In order to use the nitrogen of the air, alsike clover, as is the case with all legumes, must be infected with the appropriate nodule-forming bacteria. Fortunately, these are so widely distributed that they are present on most clover land. On new land they may be wanting, especially on burned-over land and on newly drained marsh land. In such cases the seed should be inoculated. This may be done by scattering soil from a field on which white, red, alsike, or crimson clover has made a good growth or by applying a pure culture of the proper bacteria to the seed. If soil is used, it should be spread on a cloudy day or in the evening and immediately harrowed in, as the bacteria are killed by sunlight. Pure cultures should be used according to the directions furnished with them. An important point is to keep the seed in the shade while drying.

USES.

ALSIKE CLOVER AS A HAY CROP.

Alsike clover makes the best quality of hay; better, indeed, than red clover, though where conditions are favorable for red clover, the latter will yield more hay than alsike clover. In 1916 a bunch of alsike-clover hay took the first prize at the Iowa State Fair (fig. 3). Chemical analysis shows that, so far as the composition of the hay is concerned, there is not much difference between red clover and alsike clover.

Table I[1] gives the quantities of digestible food materials in 100 pounds of hay.

TABLE 1.—*Quantities of digestible materials in 100 pounds of alsike-clover and red-clover hay.*

Kind of hay.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value (calories).
Red clover	84.7	7.38	38.15	1.81	92,324
Alsike clover	90.3	8.15	41.70	1.36	98,460

From this table it will be seen that in equal quantities of alsike and red-clover hay the alsike clover contains more digestible protein and has a higher fuel value than the red-clover hay. In certain tests of the feeding value of hays carried on by the Montana Agricultural Experiment Station in 1911 it was found that sheep fed on alsike clover made 1 pound of gain for 6.32 pounds of hay consumed and those fed on red clover 1 pound of gain for 6.43 pounds, while those fed on alfalfa made 1 pound for 6.58 pounds of hay consumed. While the advocates of alsike clover do not contend that it makes a better hay than alfalfa, good alsike-clover hay is certainly equal to the best and is better than most hays, and there are soils and situations where this clover will outyield any other crop of its kind. Then, too, the alsike clover, being a smooth plant, makes a cleaner, less dusty hay than red clover.

Alsike clover has some advantage, moreover, in being finer stemmed. There is not so much waste as in red clover, as stock clean

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[1] From Farmers' Bulletin 22, United States Department of Agriculture.

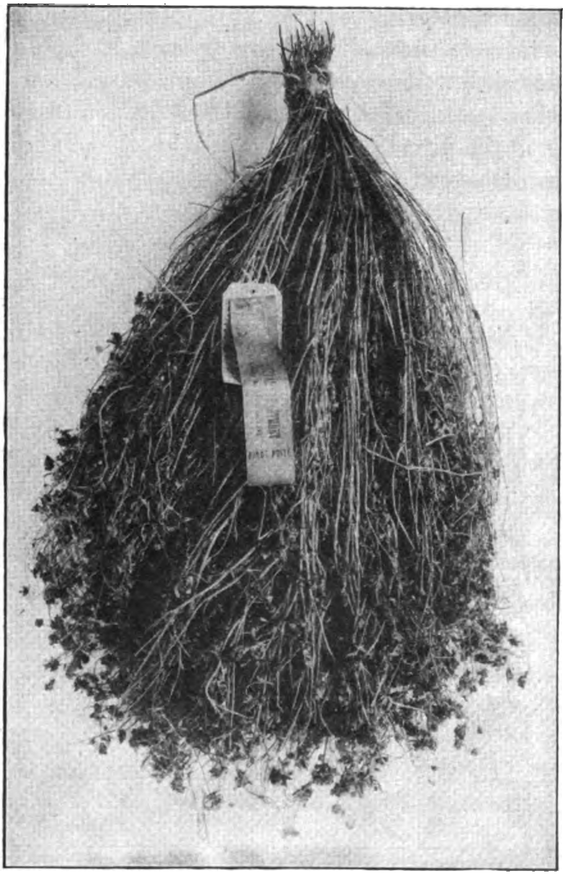

FIG. 3.—Well-cured alsike clover makes hay equal to any. The bunch of hay shown took the first prize at the Iowa State Fair.

it up better. Many dairymen consider it the best of hay, and it is noticeably most popular in the Northeastern and New England States, where it thrives best and is best known. Unfortunately, except in the Montana trial already quoted, there is no record of any definite tests having been made with alsike-clover hay as compared with red-clover hay. This is possibly owing to the fact that alsike clover for hay is so rarely grown alone. Some farmers claim that the hay has not as much feeding value as that of red clover, but the weight of opinion as well as the inference which may be drawn from its chemical composition, as shown in Table I, does not support such a view.

Because of its weak, slender stems, alsike clover usually should not be seeded alone for hay. When in a pure stand, especially on moist or wet land, the stems mat together and the plants are difficult to cut. Sown with timothy or with red clover, the weaker stems of alsike clover are supported by the more upright ones of the red clover and of the timothy, and the alsike clover acts as a filler, making the stand thicker below and thus adding materially to the weight of hay cut. Alsike hay is greener than that of red clover, and unless the stand is extremely thick it cures more readily. When the stand is thick, as it is apt to be on low, rich land, it may be necessary to do some handwork in turning it, in addition to using a tedder. A successful alsike grower in Colorado allows the cut clover to lie in the sun for 1½ days, then turns it in small windrows, and puts it in the stack in the afternoon of the third day. This grower gets heavy yields on sandy land under irrigation. It is important in handling this clover not to let it get too dry, because then the leaves and heads break off and the value of the hay is much reduced. It has been noted that alsike clover when cut will endure without serious injury a wetting that would ruin red clover.

ALSIKE CLOVER WITH RED CLOVER OR TIMOTHY.

Alsike clover is seldom grown alone for hay. Except when grown especially for the seed crop it is almost always mixed with either red clover or timothy, mostly the latter, or even more often with red clover and timothy. The use of alsike clover in mixtures has increased of late years wherever it has been difficult to get a stand of red clover. At present in many of the Northern States alsike clover is sown on probably 75 per cent of the clover and timothy acreage. When equal parts of alsike and red clover are seeded there is more alsike than red clover in the stand; when the quantity of alsike is half that of red clover, the quantity of each in the stand is about the same.

Timothy and alsike clover together make an exceptionally good hay. The alsike clover cures to the same color as timothy, and the timothy helps to keep the clover from packing when cut, so that it is more airy in the swath and cures better and quicker than pure alsike. With good weather conditions such mixed hay will be ready to rake and stack about a day after cutting. On rich, moist land it is especially important that the alsike clover be seeded with timothy or with some other grass, such as redtop, as on such land the clover grows very rank, with long stems that mat together when grown alone and lie on the moist surface of the soil. Under such conditions the lower leaves decay and some of the flower and seed heads also partly decay. This moldy, partly decayed vegetable matter may get with the hay or be eaten in the pasture. Though there is no direct evidence for the view, it is not impossible that some of the bad effects reported as having followed pasturing on alsike clover may have been due to moldy feed. This may be avoided by seeding the alsike clover with one-half or one-third timothy to hold it up. In many sections of the United States mixed timothy and alsike hay sells for the same price as pure timothy, provided the proportion of alsike is not more than 12 to 15 per cent. An equal quantity of red-clover hay would discolor the whole and reduce the grade.

Rate of seeding in mixture with red clover and timothy.—The rates of seeding mixtures of alsike with red clover and timothy, either or both, vary in different sections. Table II gives some of the formulas that are in use in the States named.

TABLE II.—*Proportions of alsike clover, red clover, and timothy used in mixtures in various States.*

State.	Rates of seeding per acre (pounds).			Remarks.
	Alsike clover.	Red clover.	Timothy.	
Illinois	2	10	5	
Do.	4	4	4	Illinois experiment station for hay.
Do.	4	4	8	
Do.	2	6	4	
Indiana	2	....	4	
Do.	2	2	2	
Maine	4–6	....	1	
Do.	7	8	8	
Do.	6	6	20	
Do.	15	15	....	Preparation for potatoes.
Do.	5	5	20	
Maryland	6	6	10	
Michigan	1	....	9	
Do.	4	8	....	
Do.	4	12	....	
Do.	6	6	....	
Do.	4	8	8	
Minnesota	1	4	8	
Do.	5	5	5	
Do.	5	....	10	
Do.	7	4	4	
New York	4	....	12–14	This is a common mixture.
Do.	2–4	3–4	9–12	
Do.	2	6	16	
Do.	4	8	8	
Do.	6	....	10	
Do.	4	4	12	
Do.	2	4–6	11	
Pennsylvania	6	6	16	Sow 24 pounds of mixture per acre.
Do.	8	....	8	
Do.	4	12	....	
Vermont	4	5	....	
Do.	4	5	15	
Wisconsin	8	....	10	
Do.	2	6–8	2	
Do.	4	4	4	
Do.	6	1	1	

Time to cut in mixture with red clover and timothy.—The best time to cut alsike clover for hay is when it is in full bloom. (Fig. 4.) It blooms irregularly, and when the field as a whole is in full bloom there will be many heads with seed which is already ripe. Fortunately, the fine stems of alsike clover do not get hard as quickly as the stems of red clover. They keep on growing and blooming as the lower flower heads mature, and consequently good hay may be made within a range of several days. When a grower wants seed as well as hay the field may be allowed to become a little more nearly mature. Both good hay and a fair seed crop may then be secured. When grown in mixture, especially with timothy (fig. 5), this characteristic of remaining good for some days is especially valuable. There is a wide range of expressed opinion as to whether alsike clover ripens for hay at the same time as timothy. The United States Department of Agriculture has on file many reports, among which some farmers in the Central States claim that it ripens with timothy and others that it ripens before timothy. This difference is perhaps due to a variation in the conception as to the time when the clover is in the best stage to cut. If it is to be cut before any heads are ripe it will doubtless be ready before timothy, but it will also remain in good condition to cut after a few of the lower heads contain ripe seeds and in that case usually will be ready for harvest with timothy. It is not desirable, however, to allow alsike clover to get too ripe, as the presence of much ripe seed is said to be one cause of the slobbering of horses fed on the hay. When seeded with red clover the hay will be at its best if cut when the red clover is in full bloom. Alsike when sown with red clover improves the quality of the hay, besides thickening up the lower parts of the stand and thus adding materially to the yield. A mixture of alsike and red clovers is said to yield a greater weight of hay than either variety alone.

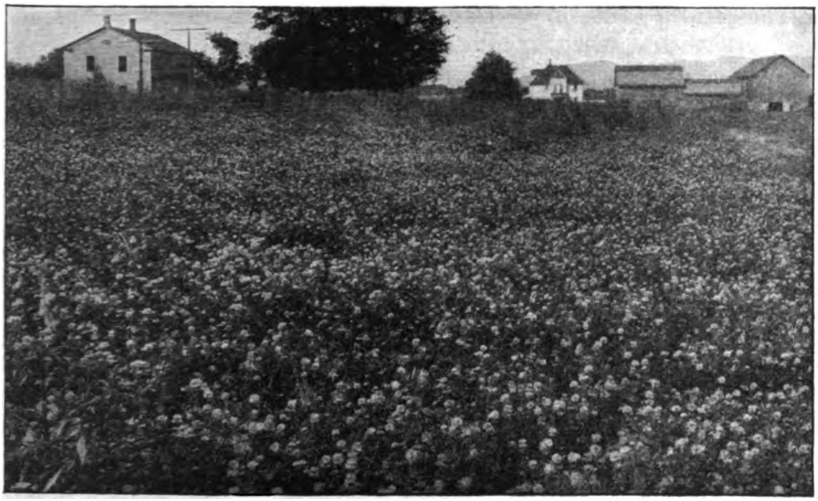

FIG. 4.—Alsike clover in New York, ready to cut.

ALSIKE CLOVER IN OTHER MIXTURES.

Besides the mixture of alsike clover, red clover, and timothy, which is by far the most common one in use, various other mixtures are recommended for different situations and sections. The Illinois Agricultural Experiment Station suggests for pastures sweet clover, 4 pounds; alsike or red clover, 4 pounds; timothy, 2 pounds. A common mixture is alsike clover, timothy, and redtop, this mixture being used on rather "sour" soils on which the timothy fails to last long. Kentucky bluegrass is sometimes added to the mixture, especially when it is designed to pasture the meadow after a year or two.

A mixture of 10 pounds of redtop and 5 pounds of alsike is especially valuable for its ability to produce profitable yields on heavy, wet land. It is of most importance for hay, although the aftergrowth will also furnish considerable pasturage. More elaborate mixtures, used to some extent, are mentioned below.

The Ohio Agricultural Experiment Station suggests for the northeastern part of the State 5 pounds of red clover and 3 pounds each of alfalfa and alsike clover. In many places the clover and alfalfa are seeded together. In western New York the writer has seen such a field when the alsike clover had made a heavy growth and no alfalfa plants could be found. (Fig. 6.) However, after the clover was cut the alfalfa came on well and made a good stand.

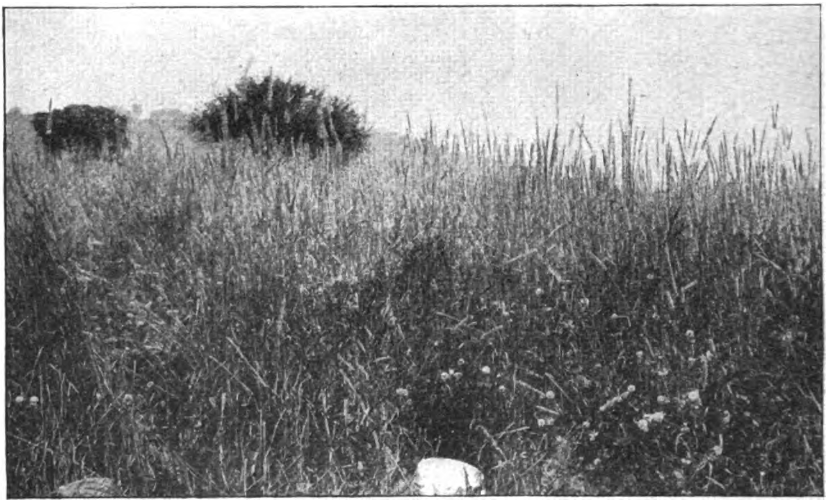

FIG. 5.—Alsike clover and timothy, ready to cut.

In Montana and Minnesota alsike clover is sometimes seeded with brome-grass for pasture.

The Idaho Agricultural Experiment Station recommends the following for irrigated pastures in that State: Redtop, 8 pounds; timothy, 8 pounds; meadow fescue, 6 pounds; and alsike clover, 4 pounds.

On the Pacific coast rye-grass forms part of a mixture with alsike clover. In Humboldt County, Calif., a mixture of 4 pounds each of alsike clover, red clover, timothy, orchard grass, and rye-grass is used.

In Virginia a mixture of alsike clover with orchard grass, tall meadow oat-grass, redtop, and white clover is said to give good results.

In Missouri certain farmers think highly of a mixture consisting of 5 pounds each of alfalfa, meadow fescue, and orchard grass with

3 pounds of alsike and 2 pounds of timothy. This can be pastured till June 1 and later cut for hay. This mixture is seeded with 1 bushel of oats as a companion crop and is pronounced a success. Another favorite mixture in the South is orchard grass, 10 pounds; perennial rye-grass, 5 pounds; redtop, 3 pounds; and alsike clover, 4 pounds. The Arlington mixture of 20 pounds of tall oat-grass, 10 pounds of orchard grass, and 4 pounds of alsike clover has been successfully used as a mixture for hay in sections south of the timothy region.

The Tennessee Agricultural Experiment Station has suggested a mixture of 5 pounds each of orchard grass and tall meadow oat-grass and 4 pounds each of redtop and alsike clover.

The seeding of alsike clover with orchard grass is not uncommon in the South, especially in Kentucky. In Franklin County, Ky., orchard-grass seed is harvested, and there alsike clover is frequently seeded with the orchard grass. If all hay is wanted the entire crop is cut when the clover is in full bloom. At this time the orchard-grass seed is not yet ripe and the grass is tender, making an excellent hay. In that section alsike clover gets overripe before timothy is ready to cut, but orchard grass replaces the timothy very satisfactorily. When the orchard grass is wanted for seed it may be cut high above the clover with a binder. After the little shocks are set in rows, four or five together, the mowers may follow and cut a fine lot of hay consisting of alsike clover and the lower parts of orchard grass.

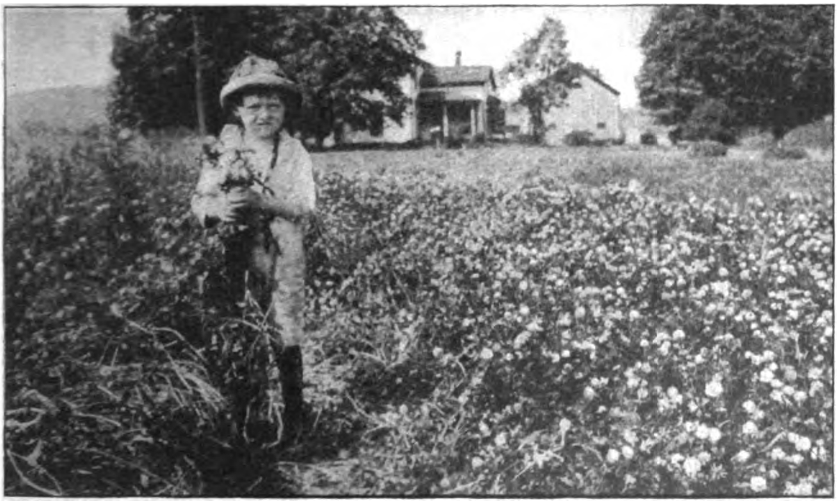

FIG. 6.—A heavy growth of alsike clover in New York. The alfalfa in this field came on later to a good stand.

ALSIKE CLOVER AS A PASTURE PLANT.

Alsike clover is especially suited for use in pasture mixtures. Its vigorous growth enables it to hold its own against the competition of other plants, and its persistence in seeding provides for its continuance. For permanent pasture on low or "sour" land alsike clover is especially valuable and may be used alone or, better, with redtop. In the South, where this clover is little used for hay, it has proved valuable as a part of the permanent pasture mixture on bottom lands. The many creek and river bottoms in the South which are hard to work because too wet to plow in spring or because of occasional floods, could be seeded profitably to a mixture of alsike clover and redtop. Where the clover has been used in this way it has given a good account of itself, having been grazed the entire summer without damage.

In the North, alsike clover is commonly seeded with timothy and red clover for pasture as well as for hay. While in the course of a rotation the fields are usually plowed after 3 to 5 years, cases are known of alsike clover having been pastured over 12 and as many as 30 years. When it is grazed or cut early it at once sends out new branches, and these will produce flowers and mature seed when not more than a few inches long; in this way the ground is constantly full of seed and the pasture keeps in good shape. Alsike clover in pasture is also more hardy than red clover; it will withstand more trampling than red clover and does not heave out as readily. In Missouri it has been found especially valuable on rocky hillsides and on flinty land; there, where red clover will not thrive alsike clover mixed with orchard grass makes good pasture. This quality of enduring close grazing and trampling also makes it valuable for hog pasture. In Nebraska, a mixture of brome-grass and orchard grass with alsike clover, the latter constituting 75 per cent of the mixture, is used and highly regarded as hog pasture and is said to be next to alfalfa in quality. If the pasture is intended to be permanent it must not be grazed too closely. The plants should have a chance to make seed, as the old roots will die in two or three years and the continuance of the pasture will depend on the seed that has fallen.

Besides its use in permanent pastures, meadows containing alsike clover are pastured before or after haying, and fields intended for seed are often pastured until late May or early June. On rich land alsike clover tends to grow very long, with few branches. If such a field is pastured, the plants put out many branches, and the number of heads and consequently the seed crop may be very greatly increased. On poor, dry soils it is not advisable to pasture before a seed crop, as, if the season should turn dry, the plants will not recover enough to make a profitable crop of seed.

A field seeded to alsike clover and timothy may be pastured advantageously in the spring if the land is rich. Under such conditions the alsike clover makes such rapid growth that it smothers out the timothy. In the North if the field is pastured from the middle of April through the first week in May the alsike clover will be held back until the timothy has made a start, and after this the two come on more evenly and the timothy supports the clover. After haying, the aftermath may be pastured, but on soils not favorable to alsike clover there will be little of this plant left after haying. On good soil, however, there is no lack of aftergrowth.

A farmer in Racine County, Wis., in 1916, cut 100 loads of alsike-clover hay from 35 acres, and in two months after haying the cattle pastured on this field produced cream that sold for a little more than $400. In Washington a similar practice is followed; the meadows are pastured until May 5 to 10, hay is cut the middle or end of July, and then the fields are pastured again. One farmer in that State pastures three times in one season, closing the field about three weeks between pasturings. When alsike clover and timothy are sown with a grain companion crop there is often good pasturage on the stubble after harvest. If the season is favorable, the clover will stand some pasturing, but this should not be continued too long, as a good growth of the clover is desirable if it is to go through the winter successfully. In sections where the snow is likely to blow it is not advisable to pasture the stubble, because the trampling of the cattle knocks the stubble down and thus lessens the protection the clover will receive from the snow.

ALSIKE CLOVER IN NATURAL MEADOWS.

Alsike clover is often sown on natural meadows, especially when these are wet or can be irrigated. Such meadows are not uncommon in parts of the West and Northwest, and on such lands the clover may either grow with the native grasses or may run them out, making a nearly pure alsike meadow. Methods for getting a stand of clover on these lands differ, but it is usually not necessary to plow. On irrigated land the natural meadow may be disked or harrowed several times with a heavy spike-tooth harrow. The broadcasted seed will start readily after irrigation, and the clover will make a large part of the hay. On sparsely grassed irrigable land alsike-clover seed may even be put in without any working. Plenty of water, enough to keep the ground looking wet, should be given until the plants are well established. After it is well established the clover will endure some drought, but does best with plenty of water. A method successfully used by a farmer in Ottertail County, Minn., seems to be suitable for use under similar conditions elsewhere. The land is a natural wet meadow, so wet that work must be done before frost is out of the ground and even at harvest time part of the crop must be cut by hand. In the fall, before snow comes, a heavy coat of barnyard manure is put on the land and left just as it comes from the manure spreader until spring. While the ground is still frozen this manure is cut up by dragging a number of times. The seed is then sown, using one part of timothy to two of alsike clover and seeding 8 to 10 pounds of the mixture per acre. This plan has been found to kill the native grasses and to establish a good timothy-clover meadow.

At high altitudes alsike clover does very well. It seems particularly adapted to high, fertile mountain valleys, often coming as a volunteer into the natural meadows and quickly making up the greater part of the hay crop.

ALSIKE CLOVER IN SLOUGHS.

Sloughs and swales are present on many farms and are often waste, unsightly places, covered with marsh grasses and sedges. When such places are not actually swampy, alsike clover can be advantageously introduced and will improve the wild hay or may even run the wild grasses out and occupy the ground. Whenever possible, the wild growth should be killed or somewhat suppressed by pasturing or plowing, but this is not absolutely necessary. The better the conditions are made the more likelihood there is for a successful stand, but if no preparation can be made it is still advisable to take a chance and sow alsike-clover seed among the wild growth in early spring. Burning off the wild growth before seeding is a good plan. Many cases are known where this has resulted in a stand that increased until the alsike clover caused the wild grasses to lodge and finally killed them. In the course of years bluegrass is likely to come in, especially if the drainage is improved, and may in time run out the alsike clover.

ALSIKE CLOVER ON OVERFLOWED LANDS.

Alsike clover is especially valuable on wet lands, not only because it will grow best where there is plenty of water, but because it will endure a certain amount of overflow without damage. No definite statements can be made in regard to the length of time alsike clover can be overflowed, especially at different stages of growth, but the experience of bottom-land farmers in widely separated sections has shown that a 1-year-old stand may remain under water for several days, or in winter and early spring even for several weeks, without being killed. More damage is done when the entire plant is covered than when merely 2 or 3 inches of water stand on the field, but stands of this clover are known to have survived being under 2 feet of water in spring. Sometimes the stand is killed, but the seed that has fallen germinates promptly when the water drains off, and a fair crop is made, or the plants may not be killed, but the crop of hay or of seed for the season may be lost. This ability of alsike clover to live or to thrive on lands liable to overflow several times in a season makes it a plant especially to be recommended for such lands. One farmer in southern Indiana had a stand of alsike clover on bottom land that was flooded for the last three weeks of May, 1918. The clover, which was in bloom, was completely under water for a week. The crop was ruined, but after removing the débris new growth came from the crowns and in May, 1919, there was a perfect stand. When the overflow comes in March or early April the crop has been known to be under water for several weeks without damage.

At the experiment grounds of the United States Department of Agriculture at Arlington, Va., alsike clover was seeded in paraffined wire baskets in June, 1918. These baskets were sunk in large tiles made water-tight and deep enough to allow for 4 inches of water above the rim of the pots. One series was flooded as soon as the seedlings were 2 or 3 inches high, so that the young plants were completely covered. The other series was left under natural conditions. The clover grew in the flooded pots, so that soon the stems and leaves were above water. Part of this series was left continuously flooded from June, 1918, to May 22, 1919, at which time the flooded plants had made very much more growth than those not flooded. (Fig. 7.)

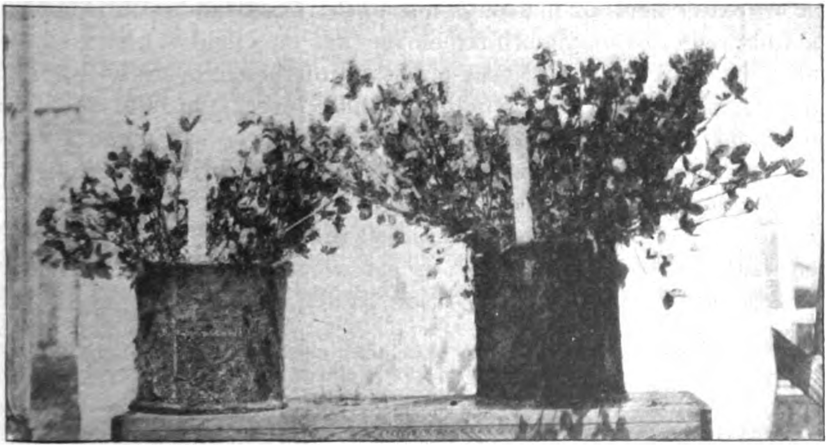

FIG. 7.—Alsike clover will endure much wet. The plant at the right has been growing in a pot completely submerged in water for a year; that at the left grew under normal conditions.

During the winter the water in the tiles was frozen for a part of the time. This experiment shows at least that alsike clover will thrive with the crowns and roots constantly under water. The roots of these plants were abundantly supplied with nodules.

ALSIKE CLOVER FOR ENSILAGE.

Very little use has been made of alsike clover for ensilage. Nevertheless, good silage is made from this clover either alone or with some grass crop or corn. Its use for this purpose is confined to northern Michigan and northern Wisconsin, where the crop is sometimes put into silos. The secret of success in making silage from alsike clover lies in thorough packing. Farmers ensiling alsike clover should have one more man trample it than is necessary in ensiling corn. The crop is put into the silo fresh and moist. If it gets rather dry between the time of cutting and putting it into the silo a stream of water is run on to the cut material. The formation of air pockets must be avoided or spoiling will result.

ALSIKE CLOVER AS A SOIL IMPROVER.

It is commonly supposed that alsike clover is not as good for soil improvement as red clover or, more especially, mammoth clover. No definite data on this subject are available. The Minnesota Agricultural Experiment Station in 1888 published a study of the roots of various clovers. In this study the fact developed that at 5 months of age alsike clover had a greater mass of roots than either red or mammoth clover, and these roots extended to a depth of 4 feet. It is undoubtedly true, however, that after a crop of hay or of seed has been cut a greater mass of matter is left to be turned under on a field of medium red or of mammoth red clover than on a field of alsike clover, and it is possible that a 2-year-old stand of these clovers will have a larger mass of roots than a field of alsike clover. On land on which red clover will not do well, however, alsike clover will make a satisfactory soil-improving crop. It has been used to bring up run-down lands when other crops failed. The number of pounds of nitrogen, phosphoric acid, and potash contained in 1,000 pounds of green red and alsike clovers, respectively, as given by Henry and Morrison in "Feeds and Feeding" (16th edition, 1916), are shown in Table III.

TABLE III.—*Quantities of nitrogen, phosphoric acid, and potash found in 1,000 pounds of green clover.*

Kind of clover.	Nitrogen.	Phosphoric acid.	Potash.
Alsike clover	6.6	1.8	9.2
Red clover	6.6	1.3	5.6

From this table it would appear that the tops of alsike clover contain per unit weight quite as much of the three chief fertilizing constituents as does red clover. From the experience of farmers in Minnesota, Wisconsin, Pennsylvania, and Michigan alsike clover may be confidently recommended as a soil improver on land where red or mammoth clover will not catch. Run-down land may be brought up by the use of this clover as well as by red clover.

SECOND CROP OF ALSIKE CLOVER.

In most cases alsike clover does not make a second growth worth cutting. This is true as this clover is generally used, though not the case in all situations and under all conditions. On river-bottom lands and on moist, rich lands in the North two crops are not infrequently secured, especially if the first crop is cut rather early, when just coming into bloom. A few days' delay here may result in the loss of the second crop. In southern Indiana a certain field of alsike clover was cut for hay three times within 120 days from seeding. The second year this field yielded two cuttings, producing in all nearly 5 tons per acre. Another field which the writer saw was seeded about the middle of March, 1917, and late in June the clover was 3½ feet high, nearly in full bloom, and ready to cut. In many sections, too, there is a fair second growth for pasture, but it is true that when mixed with red clover and timothy on run-down lands there will be only one crop and the second growth will not be enough even for pasturing. This is the one great objection to alsike clover and is the chief reason for the lighter yields of alsike than of red clover. When a second growth is made the need for winter protection should not be lost sight of in determining whether or not to cut the crop. Clover is more likely to live through a hard winter when it has 4 to 6 inches of growth than when it has been cut close in the fall and has not had a chance to make a new growth. Therefore, it should not be cut or pastured so late that it can not make at least 4 inches of growth before winter. Because alsike will not grow as fast as red clover at the end of the summer, the last cutting, if made, should not be as late as red clover would be cut, or if pastured the stock should be taken off earlier than would need to be done with red clover.

ALSIKE CLOVER AS A VOLUNTEER CROP

In many States alsike clover is especially valued for its habit of voluntarily reseeding the ground. If the soil conditions are favorable, it will come back in a field for many years. Farmers in the States of Arkansas, Kentucky, Michigan, Minnesota, and Colorado have for years practiced rotations in which the only clover crop is the volunteer alsike from an original seeding made in some cases as much as 20 years before. These rotations include corn, oats. wheat, and alsike clover, the last volunteering in the wheat and affording a seed crop. Enough seed shatters to reseed the ground and the rotation is resumed. Or the clover may simply alternate with a grain, such as wheat and clover or barley and clover. Or there may be two years of cultivated crops followed by two years of alsike clover. In Colorado a rotation of three grain crops followed by two years of alsike clover is sometimes practiced.

This habit of volunteering is due largely to the fact, as already explained, that the lower heads of alsike clover ripen while the end of the shoot is still growing and blooming and the ripe pods fall off readily when the hay or seed crop is harvested. Where conditions are favorable alsike clover will work into all parts of a farm from a small start. This is especially true if seed is harvested and may, indeed, be an undesirable feature in some sections where white-clover seed is also produced. The seeds of white and of alsike clover are so nearly alike in size that when once mixed they can never be separated. Therefore, as the alsike clover works itself into a white-clover seed section, the production of white-clover seed has to be abandoned, because it can no longer be harvested free from seed of alsike clover.

When alsike clover is fed, the manure always carries a large quantity of seed, and enough clover may volunteer in fields where the manure is spread to make a good seeding. In the West, lands are sometimes seeded from the seed carried down by irrigation water. Where conditions are right this clover will make its way into new territory, spreading from field to field, being, in fact, as one correspondent expressed it, "the only good thing to spread like a weed."

DISEASES AND INSECT ENEMIES.

Alsike clover is not seriously, if at all, affected with diseases such as trouble red clover. Most of them have not even been recorded as found on alsike clover. An undescribed species of anthracnose has been reported, but in Tennessee this clover seems immune to the disease that wrecked the red-clover plantings in certain sections of that State.

A similar statement may be made in regard to insects. Alsike clover is little troubled by the root borer, which is a serious enemy of red clover in New York and Oregon and is more or less prevalent in many parts of the United States. In Idaho the clover aphids give some trouble, but these pests may be destroyed by close spring grazing of infested fields. A field of alsike clover in Idaho was badly infested in May. It was kept grazed to the ground from that time until June 19, when the field was irrigated and the clover allowed to grow. In August there was a splendid stand, free from aphids, in full bloom. The general statement may be made that, except for the aphids in Idaho, there are no serious insect enemies and that no diseases at present known menace the growth of alsike clover.

SOME HARMFUL EFFECTS OF ALSIKE CLOVER.

In common with other clovers, alsike clover will cause bloat if stock are allowed to eat freely of the fresh plants, especially early in the season. This fact is so well recognized and the proper precautions are so well known as not to require extended discussion. There is, however, another injurious effect that seems largely, if not wholly, confined to alsike clover. This is the disease called trifoliosis by European authorities and mentioned by the Tennessee Agricultural Experiment Station in its Bulletin, vol. 8, No. 3 (1905). While this disease is not well understood, there is sufficient evidence to warrant the statement that under certain conditions alsike clover may cause sores on horses and mules. The statement is frequently made by farmers that this is especially troublesome with white-faced or white-footed horses, and some include white hogs in this class. The trouble, so far as reported, seems not to be general but to be very widespread. From Wisconsin and New York, where alsike clover is largely grown, no reports have been received. Pending further study by the experts of the United States Department of Agriculture no additional statement in regard to this matter can be made. It is well, however, for farmers pasturing stock on alsike clover to watch for signs of sore mouths or sore spots on the fore legs or body. When such are noted the animals should at once be taken from alsike-clover pastures and put on grass. Unless the disease has progressed too far they will promptly recover.

SEED PRODUCTION.

Alsike-clover seed is produced more or less throughout the Northern States as far west as Kansas and the Dakotas and in Idaho. In New England and in Pennsylvania the production amounts to practically nothing. In Maryland seed, so far as known, is produced in but one county. (Fig. 8.) The chief areas of production are western New York, northwestern Ohio, Indiana, southern Michigan, Wisconsin, Idaho, and Oregon. Smaller quantities are also harvested in Iowa, Minnesota, and Illinois. Large quantities are produced in Canada. There are, unfortunately, no data on which to base an estimate of the quantity of seed raised, but the relative importance

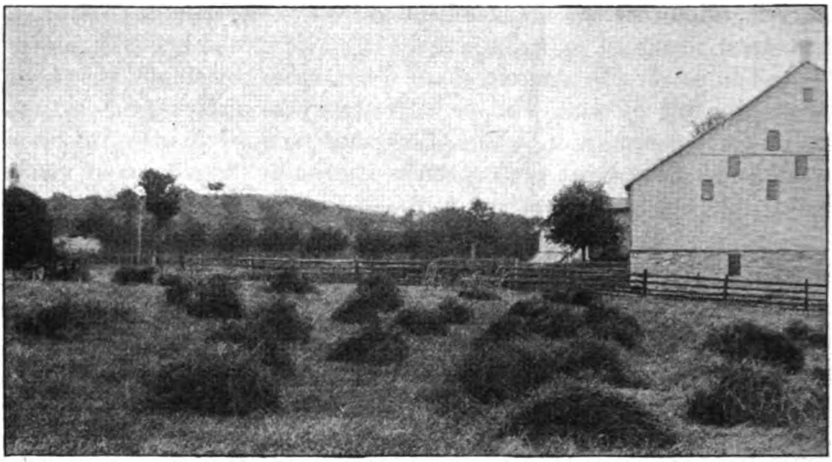

FIG. 8.—Harvesting alsike clover for hay and seed in Washington County, Md.

of the different sections as producers of alsike-clover seed is about as given above. During the past few years Idaho has come to be an important producer, much alsike clover being grown there for seed alone. The seed is taken from the first crop, which ripens some time in July or later, depending on the season, latitude, and method of handling. In some cases fields are pastured in the early part of the season, say until late May or early June. This delays maturity and the seed crop is ready to cut in August. Owing to its irregular flowering habit there will be overripe heads and buds on the same plant. Some of the older seeds will necessarily be lost, but cutting should be done when the largest number of heads can be saved, which usually will be when about three-fourths of the heads are ripe. Cutting is best done with a self-rake reaper, that the cut clover may be left in small bunches. Some take off every other rake. If the growth is rank and much tangled a mower should be used, the cutting being done in the early morning when the dew is on, and men should follow the mower to put the cut clover out of the way of the horses on the next round. Some attach a metal or canvas shallow box to the rear of the cutter bar. A man follows the mower, and as the box fills he rakes the clover off into small bunches. A buncher attachment or swather is also used. Alsike-clover seed shatters readily and great care should be taken in handling it. As soon as dry the clover should be stacked unless it can be thrashed direct from the field. In this case canvas should be laid on the wagon bottoms, so as to catch the shattered seed.

An average yield of 3 to 4 bushels per acre may be expected. Much higher yields have been recorded, 6 to 8 bushels being not infrequently secured, and reports from Idaho claiming yields of

9 to 16 bushels per acre have been received. There is no doubt that under Idaho conditions the yields are materially higher than they are in the East.

When sown for a seed crop in the East the planting should be made on the poorer lands. On rich, low land the growth is rank but the yield of seed relatively small. On the higher or poorer land the clover will be short, but the flower heads more numerous. When the growth promises to be rank and a seed crop is wanted the field may be pastured until about June 1. This will cause many additional shoots to start, each of which will bear flower heads and thus increase the yield of seed. In Idaho seed is grown on irrigated land. There information as to the number of irrigations or as to the best time to stop irrigating is not definite, but the general practice is to water only once in the spring and when one-third in bloom to water more frequently, leaving the water on for 12 hours. This frequent watering is continued until a large part of the heads have turned brown. Alsike-clover seed is also frequently harvested along with timothy seed and the mixture of these is sold as such.

In the East only one seed crop generally is taken from a field before the field is plowed. In some cases, however, from two to four crops have been taken in as many consecutive years. Weeds are, however, liable to get into the field, and it seldom pays to leave it for seed more than one year. In Idaho it is said that two crops can be profitably cut, and sometimes several. The best practice, however, appears to be to take no more than two consecutive crops. If a field is left longer weeds get into it too badly.

Some farmers cut alsike clover for seed as early as possible. This leaves many blossoms and buds, and while the seed crop is perhaps not as large as if the field had been cut later the straw makes good hay. Alsike-clover straw makes fair feed, however, even when the crop is not cut until it is too old for good hay. This straw serves as winter feed for sheep, colts, and young cattle.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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FARMERS' BULLETIN 1152

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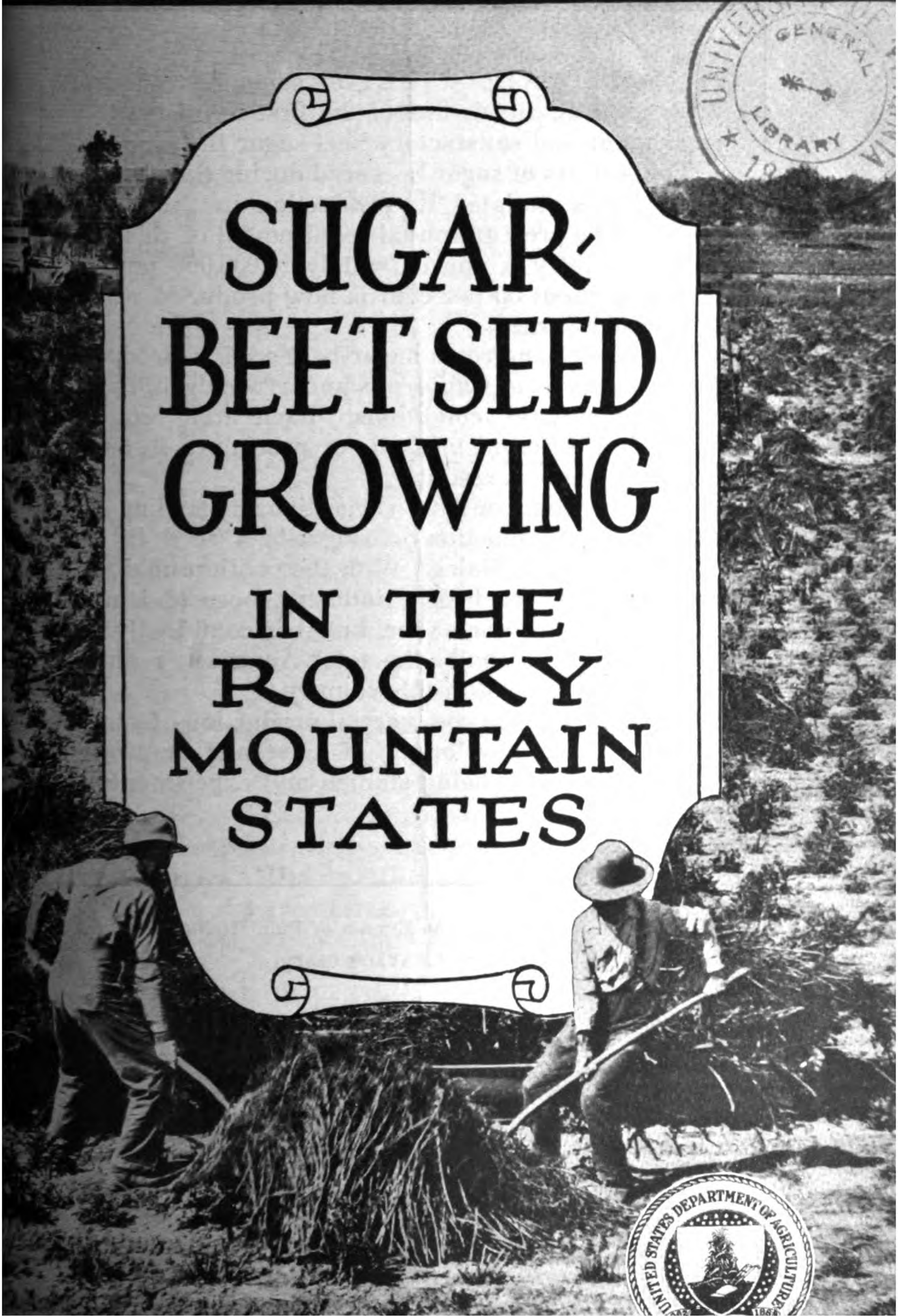

SUGAR-BEET SEED GROWING IN THE ROCKY MOUNTAIN STATES

AN ADEQUATE SUPPLY of sugar-beet seed of good quality is one of the first requisites of a permanent and satisfactory beet-sugar industry.

The scarcity of sugar-beet seed during the past few years has stimulated its production in the United States. The present annual requirement of this seed in this country is approximately 16,000,000 pounds, of which about 50 per cent is now produced within the United States.

The American-grown sugar-beet seed is produced from Michigan to California under widely different soil and climatic conditions. Each area requires somewhat different methods of procedure in order to secure the best results.

This bulletin contains suggestions regarding the commercial production of sugar-beet seed in the Rocky Mountain States. With the continuing development of the beet-sugar industry more and more seed is required each year, but it is confidently expected that eventually the total American requirement will be grown in this country.

In addition to the commercial production of sugar-beet seed the developing of new and improved strains of beets is being studied and experimentally attempted.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. October, 1920

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SUGAR-BEET SEED GROWING IN THE ROCKY MOUNTAIN STATES.

By W. W. Tracy, Jr.,
Technologist, Office of Sugar-Plant Investigations.

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GROWING SUGAR-BEET SEED AN ESTABLISHED INDUSTRY.

THE PRODUCTION of sugar-beet seed in the United States is now an established and apparently profitable industry in several sections of this country. A description of the methods followed should, therefore, be of interest to prospective growers of beet and other seed crops. The development of the industry has been greatest in the irrigated sections of Colorado, Montana, Utah, and Idaho. Rains are less troublesome in this region at harvest time than in some of the other beet-seed growing States. Irrigation makes it possible to secure a more uniform growth of plants and more certain yields of seed. There are no difficulties with plants running to seed the first year nor with stocks deteriorating, as is the case in some parts of the Pacific coast region. The writer's experience has been largely confined to this favored beet-growing region, and the practices described and the illustrations presented here have reference to this irrigated section.

Growing sugar-beet seed is best adapted to large operators, the investment required for special machinery being so great that the business is rarely profitable on less than 100 acres. Therefore, the instructions given in this article refer to operations on a large scale.

SIZE OF ROOTS FOR SEED.

The sugar-beet plant is a biennial, and the roots do not under normal conditions send up seed stalks and develop seed until the second year. Only small-sized roots, not over 16 ounces in weight, are used for commercial seed production. The 8-ounce beets are usually considered the most profitable, although those as small as one-fourth ounce will produce seed if handled with extreme care. In commercial operations it is quite impossible to use anything below 2 ounces in weight. All roots small enough to shrink or wilt badly before being set out are discarded by commercial growers.

The small roots used for commercial seed production are known among growers as stecklings. (Fig. 1.) As they do not furnish enough pulp to sample for sugar and are not indicative of the true shape and other characteristics of a strain, they can not be used for selection and stock-seed purposes. When roots are intended for breeding, the seed must be planted early and the beets thinned so as to attain full size and normal development. (Fig. 2.)

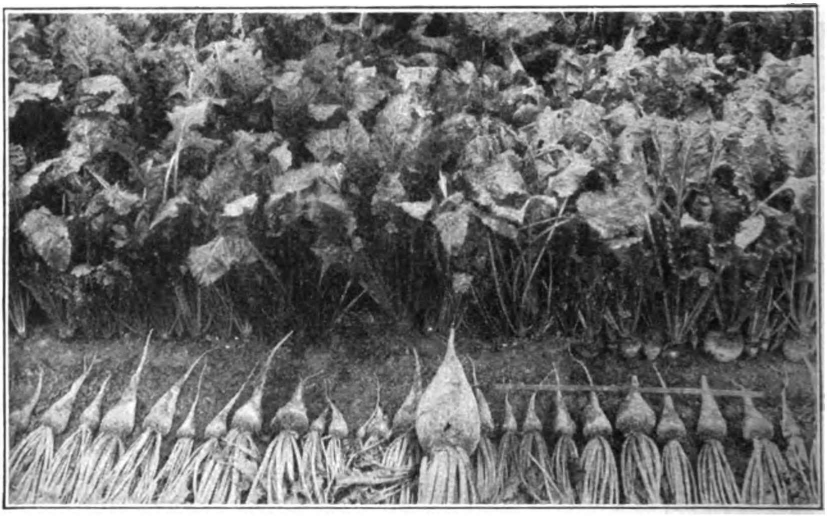

FIG. 1.—An excellent stand of beet stecklings ready to top preparatory to being pulled for siloing. The erect habit of the plants will permit very close and exact cutting, but the heavy foliage must be raked off before a beet puller can be used. The large beet in the first row is a 5-pound root placed for comparison with the stecklings that have been pulled and laid above the spot where they grew.

TIME TO SOW SEED FOR STECKLINGS.

Roots for commercial seed production are usually started about the same time as beets intended for factory purposes. Disease, however, has more time to gain headway in early plantings, and the old leaves are naturally quite broken down and difficult to cut at harvest. For these reasons some growers have better success with later sown, more erect plants, and therefore start their stecklings in June. July sowings may be satisfactory if conditions happen to be just right, but usually such extremely late plantings contain a large percentage of roots too small for profitable handling.

SPACING FOR STECKLINGS.

To keep the roots desired for stecklings from growing too large, seed is generally sown at the rate of 10 to 16 pounds per acre, and the crop left unthinned. Where the ground is in good condition and the seed of fair germination, 12 to 14 pounds is usually about right. Excellent stands have been obtained with only 6 pounds where the ground was in extra good shape and the seed of high germination.

The distance between rows depends upon the tread of the mower that is to be used to cut the tops at harvest time and whether the axles can be extended to straddle rows of any desired width. Most growers make them 20 inches apart and extend their mower axles so that the wheels exactly straddle three rows. Growers having mowers of 54-inch tread sometimes drill their rows 18 inches apart and thereby avoid the necessity of adjusting the axles.

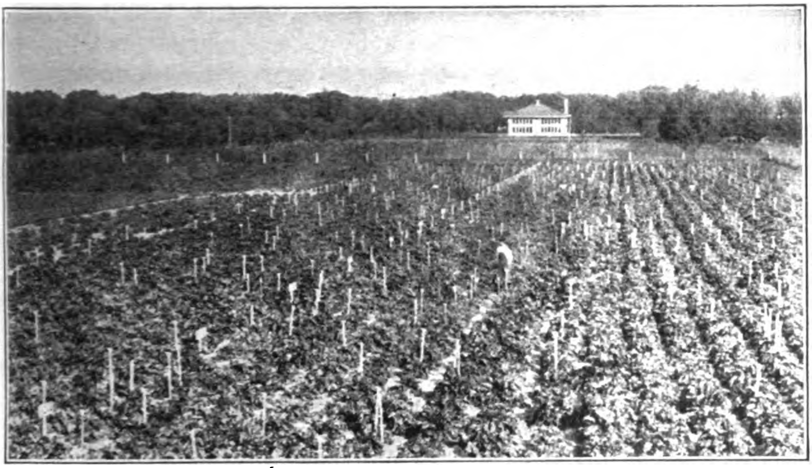

FIG. 2.—A field of pedigree beet stocks on the breeding plat of the United States Department of Agriculture being grown for comparison and further selection and improvement. The lath labels designate beets the foliage characteristics of which have been described. Later the roots will be described and analyzed for the purpose of breeding up strains uniform in foliage as well as root features.

For reasons that will be explained later the ideal steckling crop is one where the plants stand 1 to 1½ inches apart, where every root is the same in size, where none are large enough to grow out of the ground, and where the plants stand close together and are perfectly erect. An acre of such beets would supply enough stecklings to set out 20 to 30 acres for seed. In practice, however, commercial seed growers usually obtain not more than a sixfold crop.

PREPARATION FOR SOWING STECKLING SEED.

Growers should always make germination tests before planting their steckling seed and thus know what their stand is likely to be. If the seed is separated into large, medium, and small sizes and the planters adjusted according to the size and germination of each grade, a more even flow of seed and a more correct spacing of plants is possible. Usually all balls falling through a No. 10 and all running over a No. 12 screen[1] will be the small and large sizes, respectively, while those which fall through a No. 12 and over a No. 10 screen will be the medium size, generally comprising the bulk of the seed.

These measures will prove quite useless and most of the subsequent work will be futile if the ground for stecklings is not well prepared and the seeders properly adjusted. Thick sowings can not produce good stands if poorly adjusted planters drop the seed unevenly or bad spots in the field prevent it from sprouting. Good yields depend very largely upon the scarcity and the shortness of blanks in the rows. In a steckling field open spaces are especially objectionable, as will be explained later.

CARE OF STECKLING CROPS.

Where steckling seedlings are too thick, some help can usually be rendered with a hoe, especially where the sowings have been made wide by a scattering device that spreads out the seeds and makes it possible to thin out surplus plants by working sideways of the row. Stands are also often reduced by harrowing the rows crosswise. Thinning by hand costs $20 to $50 per acre and is usually too expensive to be practicable.

Unthinned stecklings standing thickly in the row show great differences in size and vigor, and large numbers of small weak-growing plants will often be crowded out by the larger growing beets. Losses from such crowding and from accidents of different kinds usually make it desirable to thin the plants so that they average about one-half inch apart. Spaced at this distance a proper proportion of the young seedlings will usually survive and result in mature stecklings, one every 1 to 1½ inches.

Steckling fields should be kept cultivated and in vigorous growing condition until harvest. It is not necessary that the plants be ripened off, as in the case of beets grown for sugar. Age and the ripening off of stecklings appear to have little relation to seed production. Soundness, proper size, and freedom from disease seem to be the most important factors.

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[1] The No. 10 standard metal screen has round openings 10 sixty-fourths of an inch in diameter and the No. 12 screen has round openings 12 sixty-fourths of an inch in diameter.

TIME TO HARVEST STECKLINGS.

Roots standing in open, exposed places and growing out of the ground may easily be ruined if the temperature goes only a few degrees below freezing, but where stecklings are still small enough to be entirely below the surface and where stands are full and the beets well protected by an erect, close, dense growth of foliage, temperatures of 20° F. or lower may cause no great damage. Instances have been reported where frozen crops have been saved by allowing the roots to remain in the ground for several days to thaw out gradually before harvesting, but the writer can not say from experience that frozen roots can actually be reclaimed in this way.

The steckling harvest should be started before freezing weather for several other reasons than because of danger to the standing crops. If, for example, harvesting is delayed until late in October, it becomes necessary to cover the silo heavily and completely very soon after the roots are pulled. Cold days and nights then are usually too frequent to permit openings to be left in the silos for a length of time sufficient to lessen the injury that may occur from heating after the roots are stored. Sudden drops in temperature may also freeze the ground before the covering of the silos is completed, leaving nothing but frozen lumps of earth for protection, which, if not mellowed later by rain and warm weather, afford but little better resistance to cold than cobblestones. Long rainy spells often make it impossible to handle soil successfully. If such rains occur late in the season and are followed by sudden cold spells, the unfavorable conditions may be prolonged until the stecklings are all frozen and completely ruined.

In northern Colorado the steckling harvests generally commence by September 20 and are usually completed, with all beets in the silos, by October 10. The final covering is commonly finished by November 10.

Unlike factory beets, stecklings must be hauled immediately after being pulled. This gathering of freshly dug roots by hand is often disagreeable and slow work if delayed until late in the season, when the beets are ice cold and wet and perhaps incompletely pulled or partially buried in soil also cold and wet.

PREPARATIONS FOR HARVESTING STECKLINGS.

Before stecklings are pulled it is necessary that the tops be cut off as close to the crown as practicable. The only economical way of doing this appears to be by mowing. If the mowers are run down first one way and then back again (fig. 3), many leaves will be cut off which would not be removed if the machines were run in one direction only. Close and uniform cutting is quite impossible where rough ground or uneven irrigation furrows interfere with the steady run of the mower. An irrigation ditch should always be made after every row. If made only after every other row, one wheel of the mower will have to travel in a depression and cause the sickle bar to run on a slant and cut unevenly unless continual attention is given to proper adjustment.

The gathering of stecklings is sometimes quite difficult when small roots, plowed out of dry soil, lie compacted in large hard clods or are deeply buried in the upturned soil. To make stecklings plow up properly it is therefore frequently necessary to irrigate before harvesting. These irrigations should be given in plenty of time to allow the soil to dry out sufficiently for running a mower through the field. If this is not done or if frequent rains or dews leave the ground or the foliage in a wet condition, the mower will clog badly and completely block harvesting operations, sometimes for several days or until other means of removing the tops are resorted to. These conditions are especially likely to occur when harvesting is started late.

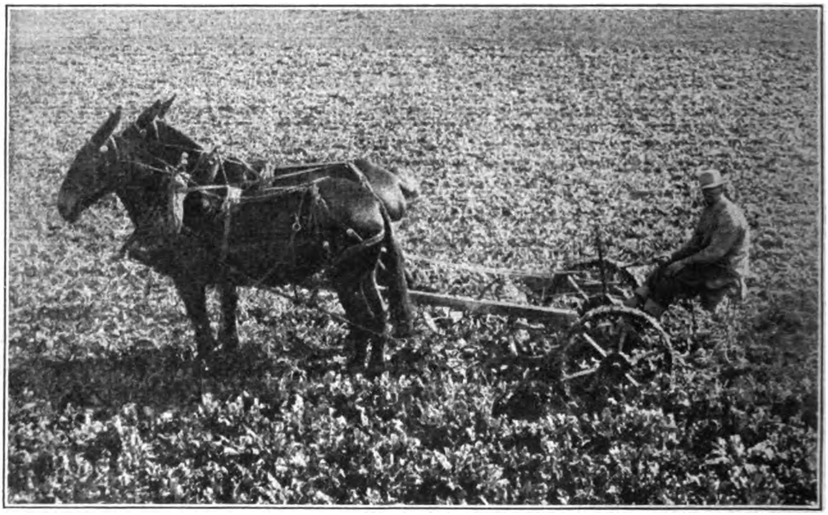

FIG. 3.—A mower cutting off the tops of beet stecklings that are to be pulled in a few days with a beet puller. The plants are too spreading and broken down by age and disease to make thorough cutting possible. The mower has run down three rows in one direction and is now coming back over the same rows to cut off the leaves not removed in the first operation.

Thorough cutting of the tops by the mower is possible only where the steckling stand is uniform, the tops erect, and the ground and irrigation furrows regular and smooth. Where numerous open places permit a considerable portion of the roots to grow large and out of the soil and the foliage to spread out flatly, or where disease, hail, wind, and other causes produce many dead and broken leaves, it becomes quite impossible to use mowing machines successfully. In such cases sharp hoes may be used to remove the tops, but this is an exceedingly slow and costly operation, especially where leaf-spot has resulted in numerous dead flat-lying leaves. If the bulk of the foliage can not be removed, the stecklings must be stored thinly in the silos.

If the foliage of the stecklings is thick and heavy, it pays to gather the leaves and silo them for feed. Raking is absolutely necessary where growth is extra heavy. Unless it is done, the beet puller clogs badly and many roots get mixed with the abandoned foliage and lost. In general, the tops are neither raked nor gathered for feed. The usual custom is to allow them to wilt until a puller can be run through the rows. Most of the leaves finally get buried in the soil, dry up, or blow away.

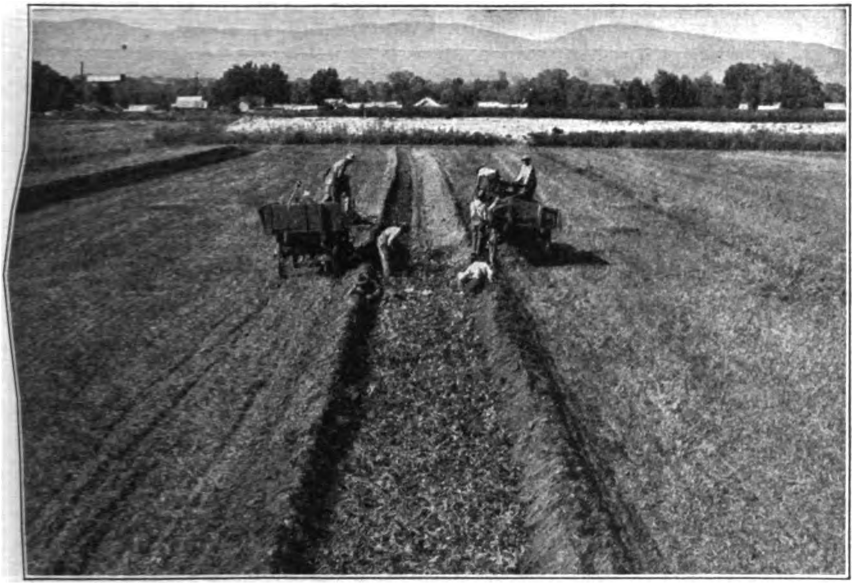

FIG. 4.—Freshly pulled beet stecklings being pitched from wagons into a silo. Two men will presently spread out the roots evenly and build earth partitions every 50 to 100 feet. Toward evening plows will throw a few inches of earth over the roots that have been placed in the silo during the day.

SILOING STECKLINGS.

Stecklings are siloed in long trenches made with plows, irrigation "A's," and road graders. The trenches are usually a rounded V in shape, as shown in figure 4. The roots are piled up to the level of the original surface, generally about 18 inches deep at the middle and 4 inches or less at the sides. Divisions are made every 50 to

100 feet by walls of earth, so that if disease starts in one place it can not spread to other sections.

Where stecklings are stored on the same ground on which they are grown, trenches are made every 70 to 100 feet or at every fortieth to sixtieth row. This method does away with long hauls, but is objectionable because it ties up large tracts of land from fall, winter, or early spring plowing and leaves the fields in a rough condition that requires much grading to put it in shape for irrigation. Level fields that have once been used for silos may be left so uneven that for many years afterwards irrigation will be difficult. For this reason many people prefer to haul their beets to fields where irrigation is not practiced or to locations where the grade is steep and where siloing does less harm.

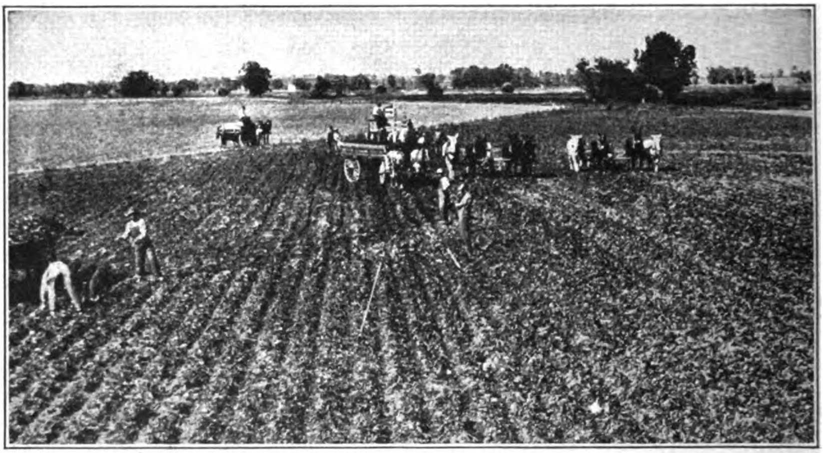

FIG. 5.—Pulling and gathering beet stecklings for siloing. The beet pullers on the right are successfully lifting out the stecklings for gathering after the mowed tops shown in figure 3 have become sufficiently dried to permit the use of a puller without clogging. In order to prevent wilting, the roots are being gathered within a few minutes after being pulled.

All stecklings must be gathered as soon as they are pulled. (Fig. 5.) A few hours of drying weather or of hot sunshine on small roots is very serious, because it greatly impairs the keeping and seed-production qualities of the crop. Beets left exposed to the hot sun too long go into the silo very warm, become heated, and may soon be ruined.

At the close of each day's operations all newly filled silos are covered lightly by means of plows or irrigation "A's." The centers are left open at first if there is danger of heating. As soon as one length of silo is complete the permanent winter covering is begun and continued until the roots are protected with at least 30 inches of earth. As this work requires considerable time, it must be commenced early in order that it may be finished before winter sets in. In northern Colorado growers plan to have all silos completely covered by November 10. In order to provide equal protection to all beets against sudden cold spells, covering operations proceed gradually and about equally on all silos.

The first earth is thrown on with plows, irrigation "A's," and road graders, but the high covering required in northern Colorado is soon beyond the capacity of these implements, and elevated road graders are used for most of the work. (Fig. 6.) These graders are expensive machines and require a 35-horsepower tractor or 12 horses to pull them.

Chimneys or ventilation flues made of straw or boards reaching from the interior of the silo to the outside air are often recommended by horticultural writers for different root crops. In northern Colorado their influence seems to extend only to the beets immediately surrounding the openings and to be quite negligible. They are not used at all by large operators.

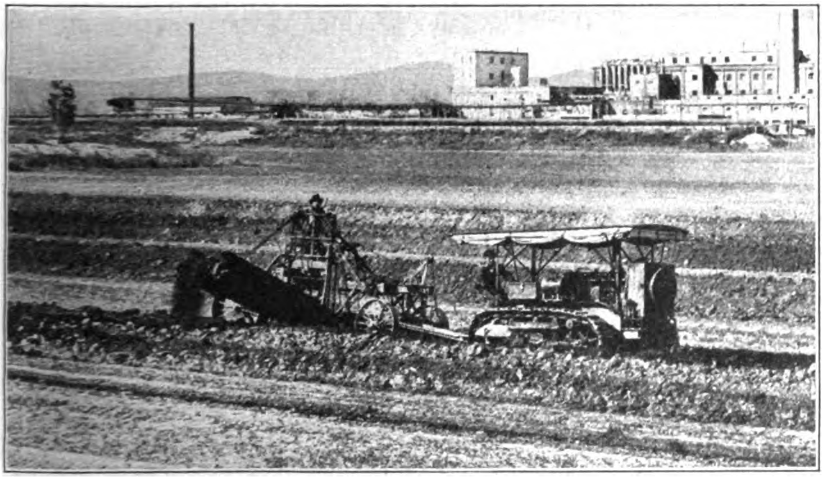

FIG. 6.—An elevated grader, such as contractors use on road work, plowing furrows 14 inches wide and 10 inches deep and spreading the earth over a beet silo. Traveling at the rate of 2 miles an hour, this grader moves more soil than 100 men could handle with shovels. A 35-horsepower tractor pulls the grader, and two men operate the outfit. In order to get enough earth to cover the beets, the grader must plow 20 feet on each side of the silo.

For reasons that are not always explainable, roots often sprout badly in the silo. Such sprouting is not serious unless it proceeds so far that flower stalks develop. The entire absence of sprouting is a pretty sure indication of diseased and worthless beets. The best yields are obtained from stecklings coming through the winter with small sprouts over the entire crown, none over three-eighths of an inch long. Less than 5 per cent of such beets are likely to be affected by disease, and practically all are as solid as when pulled in the fall.

The sprouts that start in the silo dry up and become rubbed off during the transplanting operations, and seed is produced only from the shoots that start after the roots are set out.

TRANSPLANTING STECKLINGS.

Stecklings usually give the largest yield when planted very early. In northern Colorado transplanting commences the middle of March if the weather is favorable at that time. All work is rushed so as to be completed, if possible, by April 15 or earlier.

The covering of the silos down to the level of the original surface is removed with plows, road graders, and special contrivances resembling long irrigation "A's." (Fig. 7.) The few inches of soil remaining after these implements have done their work is easily scraped off with hand shovels. The roots are immediately sorted into three sizes. The large beets comprise everything over 3 inches in diameter; the intermediate, everything between 1½ to 3 inches; and the small, everything below 1½ inches. All diseased beets are discarded.

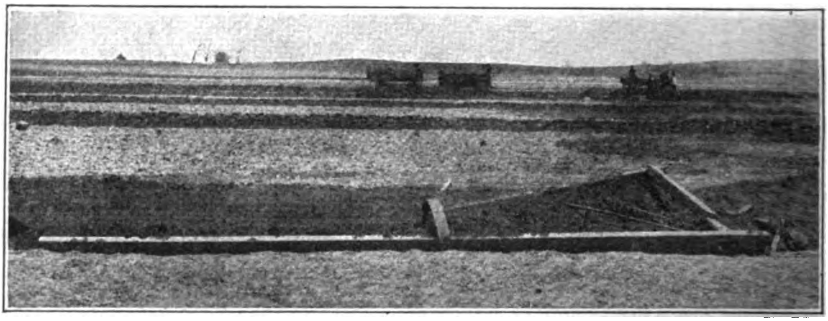

FIG. 7.—Leveler, in use for uncovering beet silos, 20 feet long, 7½ feet across, made of lumber 18 by 3½ inches. Rear opening, 18 inches. The silo over which the leveler stands has been worked down to the original surface of the ground, and the stecklings are ready to take out as soon as the few inches of earth remaining have been removed with shovels.

Stecklings usually start better and are more easily planted when their taproots are cut off to the solid portion. The lower, limper part generally curls upward when the roots are set out, and being more or less bruised and dried is seldom of any service.

Where stecklings are over 20 ounces in weight they may be divided lengthwise and each half planted like a whole root. This practice is of decided advantage only with roots weighing 2 pounds or more. It never pays purposely to permit roots to grow large with the intention of halving them.

Stecklings are planted in rows 36 inches wide and are distributed by gangs who carry the roots in sacks and drop the beets 20, 16, or 12 inches apart, depending upon whether they are large, medium, or small in size. Planting gangs immediately follow, setting the roots out, sometimes with shovels and spades, and sometimes sticking them into loosened soil made by running a subsoiler, a modified alfalfa renovator, or other specially regulated digger down the row. (Fig. 8.) If a subsoiler is used it must be symmetrical, so that it will stir the earth equally on both sides of the row. If this work is properly done, the roots can be shoved far enough down into the soil to permit earth to fall over them, so that transplanting can be accomplished entirely by hand and without an additional covering operation.

When the roots are set out with shovels or spades the earth is tamped around each beet with the heel of the shoe. When subsoilers are used the earth is packed by a special machine consisting of two heavy beveled rollers. These straddle the rows in such a way as to exert an inward and downward pressure that firms the soil close to the roots.

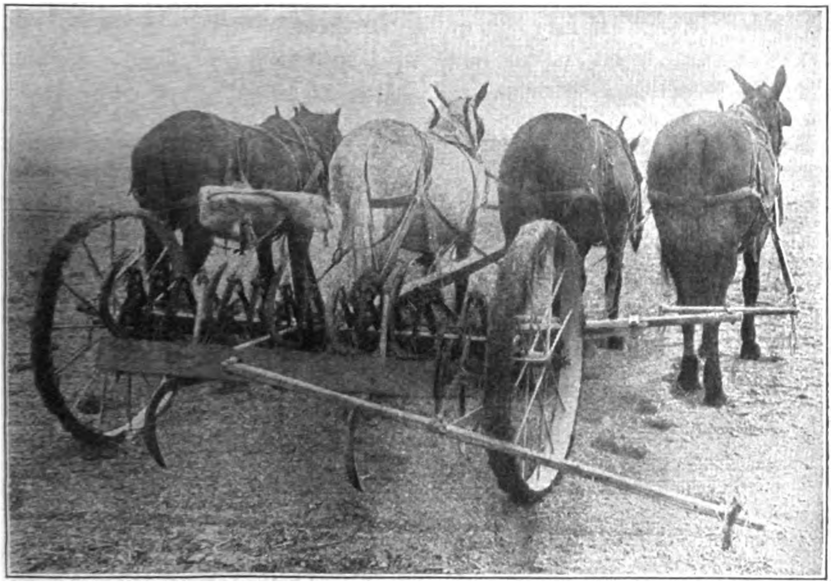

FIG. 8.—An alfalfa renovator, with some of the cultivator teeth turned up, standing ready to make 10-inch deep slots in the earth, so that two rows of beet stecklings can be set out by shoving the roots into the loosened soil. Orchard cultivators and other similar implements of equally strong frame can also be fitted for this work.

The feeding hairs of a beet plant grow at the lower part of the root. Firming operations should therefore be directed principally to packing the soil around that portion rather than about the upper part of the beet. The surface of the soil generally gets sufficiently packed by rains and irrigations, but the deeper part needs solid firming, heavy irrigations, or soaking rains to close effectually all air spaces. Firming around the tips of the beets is especially important where shovels or machines have dug too deeply into the soil and established large air spaces. If these are not at least partially closed by solid firming or rolling, soaking rains or heavy irrigations are likely to drag small stecklings so far into the soil as to make it impossible for the shoots ever to reach the surface.

The success of a beet-seed crop depends greatly upon how thoroughly the earth is firmed around the roots at transplanting time. If the beets could be set out as solidly in the ground as they grew in the fall, they would start immediately. Tamping and rolling can never approximate this ideal condition as closely as a thorough irrigation. Only a decidedly soaking rain will take its place. Whether the soil is dry or moist at transplanting time, furrows should always be made for irrigating, and no transplanting should be started until it is certain that water can be obtained immediately after the roots are set out.

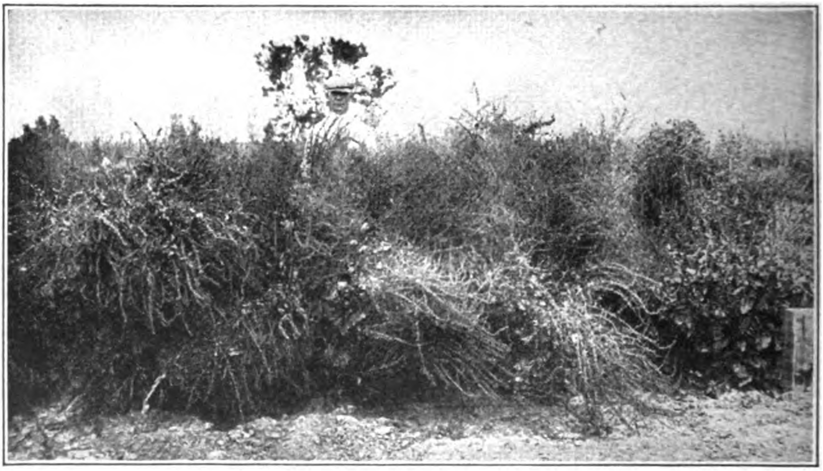

FIG. 9.—An extraordinarily heavy growth of beet seed ready to cut within 10 days. Some stalks are less ripe than others, but the plants are so matted together as to make separate cuttings impossible. The field promises a yield of 3,000 pounds of seed to the acre.

Stecklings start most easily when covered with only about one-half inch of soil. This light protection is safe when all danger of a freeze is past, but early plantings require 1 to 2 inches of covering. Shoots will occasionally break through 3 inches or more of soil without being appreciably weakened. The greatest injury occurs when rains come after the shoots have gotten part way through the soil. Such rains are damaging because they pack the soil around shoots that have previously been working through loose earth. Suddenly deprived of the air spaces they have developed, the young sprouts often rot or bend over without ever being able to work through. After rains many soils crack. This often saves deep-planted stecklings if they have not already sprouted. It will also save sprouted stecklings if the cracks appear before the shoots have been smothered.

Some eastern growers are said to have better success when the crowns are not covered with earth. In the dry air of irrigated sections such exposure causes a shriveling up of the young shoots almost as soon as they develop. For this reason some covering is necessary in the Rocky Mountain States.

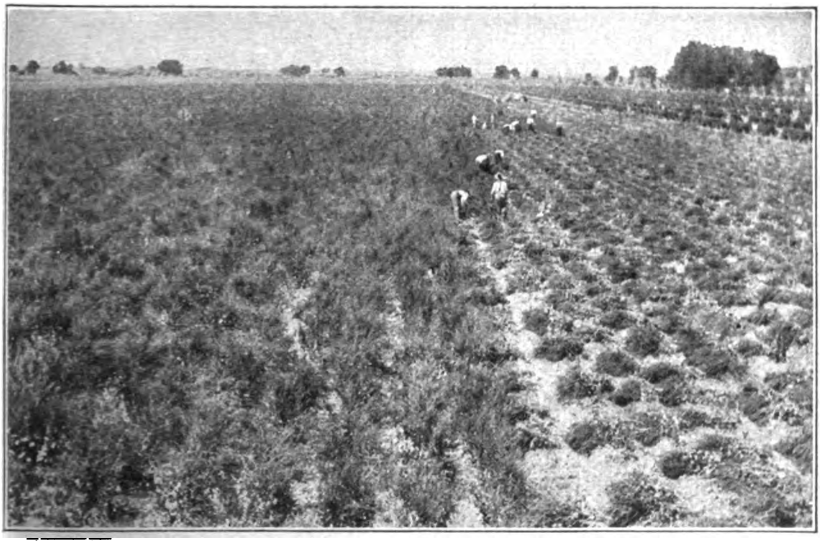

Fig. 10.—An ordinary beet-seed crop being cut and shocked. The stalks have been left in the sun for a long time and have become so wilted that they can not be made to stand up in shocks without first being tied into bundles. The field promises a crop of 1,500 pounds of seed to the acre.

CULTIVATING SEED CROPS.

Beet roots naturally start quickly, and early cultivations are very important. If the soil is not stirred after the first irrigation, the earth frequently shrinks away from all but the lower part of the roots. This results in a general drying up of the beets and a decided unevenness in the maturing of the crop. Where the growth of seed stalks is heavy and the matting together of plants complete, as it often is in irrigated sections, different cuttings can not be made, even if some plants mature earlier than others. (Fig. 9.) For this reason roots should get an even start, so that all plants will ripen at about the same time.

Beet seed stalks grow rapidly, sometimes 2 inches a day. This quick growth makes it imperative that the plants be cultivated and irrigated when they require it. If a steady, even development is not maintained throughout the blooming period the blossoms are likely to blast and much chaff result at harvest time. If growth is checked during the seed-setting stage, many partly developed seed germs may shrivel, and what appears to be a fine crop may turn out at thrashing time to be mostly empty hulls.

Beet seed is sometimes of low vitality even when growing conditions have apparently been favorable. Whether any particular low germination is due to hot winds or drying weather and a consequent shriveling of the pistil or drying of the pollen, or to incomplete fertilization arising from other causes, or to improper cultural treatment can not always be definitely determined. Much is yet to be learned along these lines. In general, seed is likely to be good where pollen is abundant. Its presence in quantity is shown by a characteristic strong odor that extends far from the fields. During the middle of hot days plants often wither a good deal, but this should cause no concern unless the stalks droop very considerably or fail to freshen up toward evening.

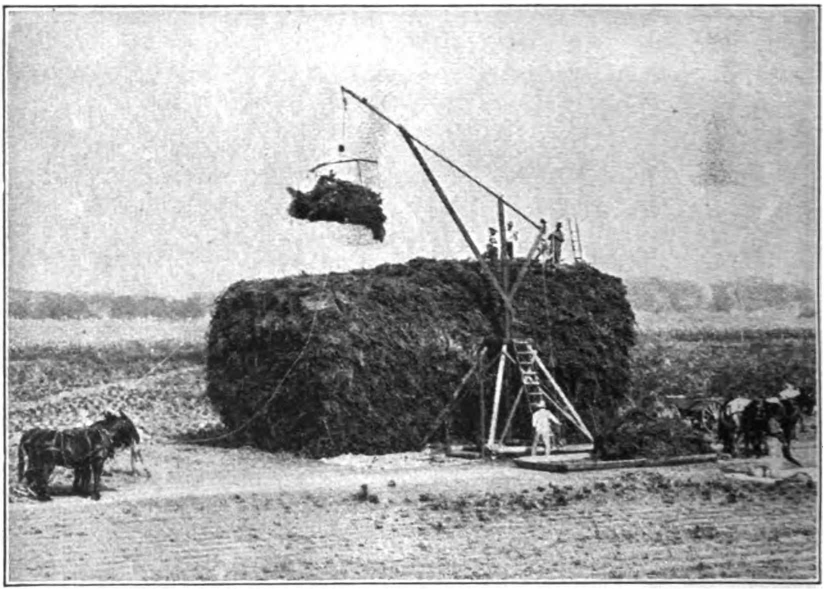

FIG. 11.—Beet seed being lifted from sleds and stacked for thrashing. Two nets have been placed on each sled, and two operations will empty a 2,500-pound load in eight minutes. Four men build the stack, four teams of three horses each haul the seed, and two crews of two men each pitch the shocks on the sleds, as shown on the title-page. Two men operate the derrick and one drives the team. This crew of 15 men, including drivers, and 14 horses will stack 10 acres a day.

Diseased or injured beets or those weakened in breaking through a hard crust may make a vegetative growth of blind seed stalks and remain green and continue to grow until freezing weather. Such plants are called trotzers when the vegetative growth is complete, and half trotzers when some seed-producing stalks are put forth. The roots of the former are usually of mammoth size, very fleshy, and make excellent feed. Those of the latter are smaller, less crisp, and are not as good feed. Roots which have borne a heavy crop of good seed are usually small, hard, woody, and totally unfit for anything.

Trotzer development sometimes appears to be due to the stecklings getting a second growth in the fall. Owing to a drought or other check occurring in midsummer, the plants stop growing and the roots become hard and remain dormant for several weeks. When refreshing rains come and the weather is cooler, such roots often start to grow again and apparently lose the tendency to produce seed the following year. The beets may keep over winter perfectly and start out early and vigorously in the spring with every prospect of good seed crop, but most of the plants may turn out to be trotzers and cover the whole field with a dense vegetative growth.

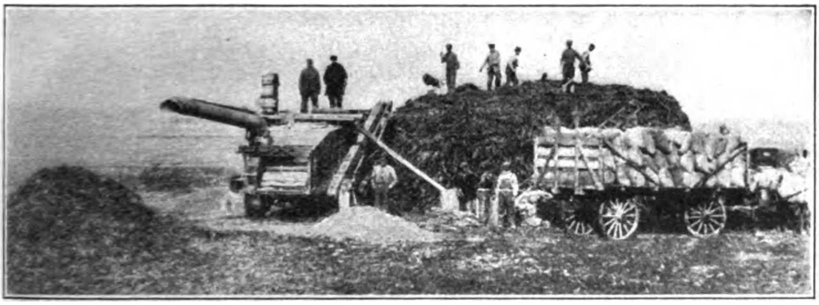

Fig. 12.—Rear view of an ordinary separator fitted to thrash beet seed. A crew of 10 men can thrash 30,000 pounds of seed a day, and two men can haul the thrashed seed to the warehouse.

The yields of sugar-beet seed in the Rocky Mountain States average approximately 1,000 pounds to the acre, with a range of 300 to 3,000 pounds. (Fig. 10.) Yields of 2,000 pounds are uncommon, while 3,000 pounds per acre is the largest yield which has so far come to the writer's notice. (Fig. 9.)

False chinch bugs and webworms sometimes damage or entirely destroy seed crops in the West. The former are difficult to control when once they appear in a field. Nicotine and soap sprays and shaking the bugs into pans containing a thin film of oil have been recommended, but the writer has never found these remedies effective after the insects appear in large swarms. If infested areas can be located, great numbers may be killed in winter and early spring by burning the dead weeds and other rubbish in which they harbor. Plants frequently escape harm if set out early, so that they come into flower before the insects appear in large numbers. Webworms may be destroyed by Paris green sprays applied from large high-wheeled sprayers with elevated bodies that can be driven over the tops of the plants.

HARVESTING SEED CROPS.

In arid sections of the United States beet-seed crops may safely be cut while the foilage is still green and before the seed balls have become dry enough to shatter. (Figs. 9 and 10.) In northern Colorado this period is usually during the latter part of July or the first part of August. A great deal of experience is necessary to decide when a crop is ripe enough to give good seed and still green enough to harvest without shattering. The right time depends principally upon when most of the seed balls have reached the dough stage. (Fig. 10.) Harvesting usually must be done quickly, within the course of a few days; otherwise much of the best seed will get too ripe to gather without shattering.

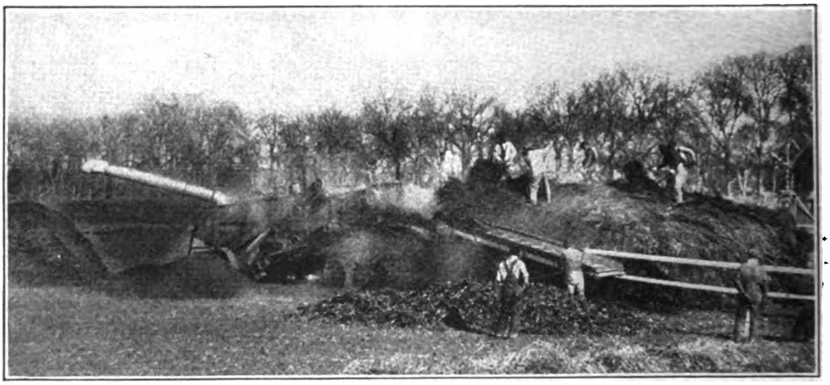

FIG. 13.—Side view of the beet-seed separator shown in figure 12. When the men on the stack can not keep the seed spread out evenly on the straw carrier, an additional man is sometimes specially detailed for this work. Even feeding results in decidedly cleaner seed.

Beet stalks should be cut close to the ground with hand sickles and immediately shocked in bundles about 30 inches wide at the top. If allowed to wilt badly before shocking, the green stalks are difficult to set up straight. In 10 to 20 days they are usually dry enough to thrash or stack. (See illustration on the title-page.) Rains sometimes make it necessary to open up and reset shocks so that the seed can dry out without sprouting. This overhauling shatters considerable seed and is costly in time and money. Every endeavor is therefore made to thrash or stack the seed as soon as it is dry enough.

THRASHING SEED CROPS.

Thrashing beet seed is comparatively slow work, and where crops are hauled direct to the machine from the field a large part of the shocks necessarily remain exposed for many weeks to damaging rains. For this reason Rocky Mountain growers almost invariably stack their seed and get it under cover as soon as possible. (Fig. 11.) Thrashing is done in the late fall or early winter and at a time when labor is most available. (Figs. 12 and 13.) If rains or storms occur, thrashing can proceed immediately after they are over, as it is not necessary to wait for long periods for stacks to dry out. Heavy dews also do not interfere with early-morning operations, and in many ways thrashing progresses with less interruptions when the crop is stacked.

Stacks are made in the field, generally one to every 10 to 25 acres. If properly built, of correct shape, and well protected at the top with straw, they will keep through almost any weather. (Fig. 14.) The greatest danger comes when rains or storms appear suddenly while the stacks are being built or during thrashing.

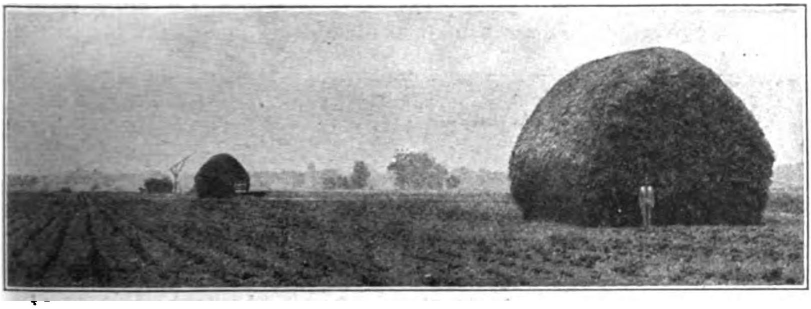

FIG. 14.—Well-built beet stacks similar in size and form to alfalfa stacks. The tops are protected with 2 feet of straw.

Beet-seed shocks are hauled most economically from the field on flat sleds about 10 by 18 feet in size, built with sloping sides about 1 foot high. (Fig. 15.) Such sleds are best because the seed can be loaded by two men, without the use of canvas and without the loss of seed. Wagons are not liked, because three or more men are necessary for loading and because canvases have to be dragged from shock to shock to catch seed that falls from pitching so high. Wagons carry somewhat larger loads than sleds, and only two instead of three horses are required, but the saving of labor in loading is compensation. Seed is unloaded from the sleds to the stacks by the use of slings and stackers. (Figs. 11 to 15.)

Sugar-beet seed is satisfactorily thrashed with ordinary grain separators and equipment, except that the feed carriers are considerably extended, the wind and speed much reduced, and lip sieves substituted for grain sieves. The teeth of the cylinders must sometimes be increased and sometimes reduced, and other adjustments, which an expert thrasher will recognize, are often necessary.

In well-regulated separators the thrashed seed will contain not more than 15 to 25 per cent of trash. Seed is occasionally blown over into the straw pile, and it sometimes pays to rethrash. Second thrashings require only one-sixth to one-third of the time required for the first and turn out less than 2 per cent to more than 10 per cent as much seed, depending upon whether the first operation was thorough or incomplete. Tare in second thrashings is very large, sometimes 80 to 90 per cent.

CLEANING SEED CROPS.

Sugar-beet seed is one of the most difficult, expensive, and disagreeable of all seeds to clean. Special equipment, such as only specialists and large operators can afford, is absolutely necessary for turning out a merchantable product. The seed is first run through a side-shake grain cleaner of large capacity, consisting of at least three series of sieves. The mill must be well equipped with traveling brushes kept in good condition at all times. The sieves of standard cleaners have too long a run, and to prevent too many stems falling through with the seed it is necessary to construct sieves with the lower two-thirds blank.

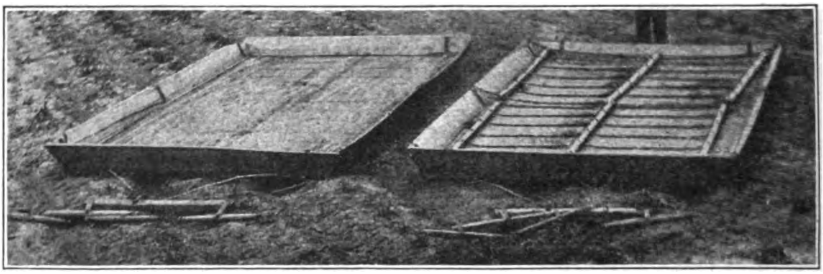

FIG. 15.—Sleds used to haul the beet shocks to the stacks, showing their construction. A double floor is made by nailing matched lumber to the upper and lower sides of five crosspieces of 2 by 6 inch scantling. The sleds pull best without runners. After several years' use the bottom floor becomes worn and the upper one full of cracks, and both must occasionally be replaced. The sled to the right shows how the slings are placed.

Properly adjusted grain cleaners generally remove the greater portion of the sticks and other trash in one operation. If they fail to do this, recleanings should be made until the mills have done all that might reasonably be expected of them. Whatever sticks are not removed by the cleaners must be taken out by running the seed over inclined canvas aprons moving over large rollers. This operation is exceedingly slow and expensive, and it does not pay to run seed over aprons when it contains sticks that can be taken out more cheaply by rapid-working grain cleaners.

The efficiency of a seed-cleaning house depends largely upon the right proportion of sieves and seed drapers. If the surface of the former is too small, the revolving aprons may very easily be overworked and fail to clean the seed properly. The canvas cleaners now in use by American growers contain apron agitators, cleaning brushes, and many fine adjustments that make them greatly superior to the German drapers in use eight years ago. Well-equipped seed-cleaning houses are to-day supplied with efficient suction drafts, which very largely remove the dust that formerly made beet-seed cleaning so disagreeable.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

FARMERS' BULLETIN 1153

UNITED STATES DEPARTMENT OF AGRICULTURE

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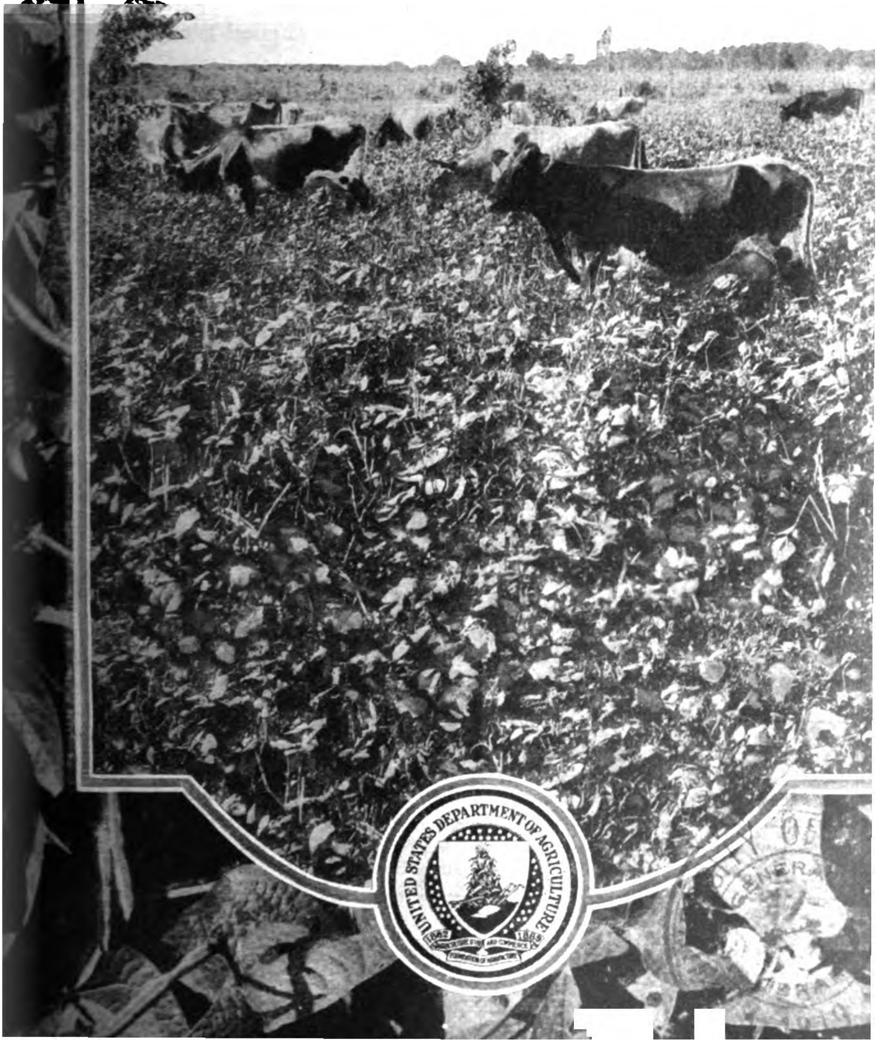
COWPEAS UTILIZATION



THE COWPEA PLANT may be fed to live stock as pasturage, hay, or ensilage, and the seed may be used as human food.

Cowpeas are not grown for seed more generally because of the uncertainty of the crop, the expense of harvesting, and the low yield commonly obtained. These factors have created a relatively high price for the seed.

In localities well suited to production it will be found highly profitable to grow cowpea seed on a large scale, especially if the best machinery for handling the crop is used.

Harvesting cowpea seed can be done most cheaply by the use of machinery. The crop may be cut with a mower, self-rake reaper, or bean cutter. When the plants are thoroughly dry, the seed may be thrashed with an ordinary grain separator with modifications, or, better still, with a machine specially constructed for thrashing cowpeas.

The seed has a high feeding value, but is rarely cheap enough to use as feed. It is fed to some extent to poultry.

The cowpea is generally and favorably known in the South as a staple human food, being used in the pod, shelled green, and shelled dry.

Good cowpea seed can be stored for a considerable length of time without much danger of loss of vitality.

Cowpea hay is an excellent roughage for all kinds of stock. When cut at the right stage of growth and properly handled, the cowpea is equally as nutritious as the hay from other legumes and is greatly relished by all farm animals.

The hay is somewhat difficult to cure, but with attention to the stage of growth and to weather conditions, little more trouble will be experienced in obtaining well-cured cowpea hay than red-clover or alfalfa hay.

The cowpea alone has not given good results as a silage crop, the best silage being obtained when it is mixed with corn or sorghum.

Although pasturing cowpeas is not considered the best farm practice, under certain conditions it is advisable and quite profitable.

As a soiling crop the cowpea can be advantageously used to supplement crops with less protein, such as corn, sorghum, and millet.

The cowpea has been used more as a soil renovator than any other legume because it is so easily grown, has such a marked effect upon succeeding crops, and succeeds under such a great diversity of conditions.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. September, 1920

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COWPEAS: UTILIZATION.

W. J. MORSE, *Agronomist, Office of Forage Crop Investigations.*

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THE PRINCIPAL USES OF THE COWPEA.[1]

THE COWPEA is of ancient cultivation for human food, particularly in Africa and Asia, and also in the Mediterranean region of Europe. Although in the United States it has been grown mainly for soiling, hay, ensilage, and pasturage for all kinds of stock and as a soil-improving crop, nevertheless the seeds, chiefly of the Blackeye and White varieties, have been commonly used for human food in the Southern States.

For feed the cowpea is especially valuable, because it will grow on all types of arable soil, requiring little attention and producing most excellent forage. In addition, it is of great value as a green-manure crop to increase the humus and the nitrogen content of the soils upon which it is grown.

Cowpea hay should be substituted in the Southern States for much of the hay which is now being purchased in the North and West. The greater use of this crop for hay and pasturage increases the production of live stock, an essential factor in securing the maximum returns in any system of agriculture. It also aids much in keeping the soil in good tilth and maintaining its productiveness.

COWPEAS FOR SEED.

On a very large proportion of the area planted to cowpeas, little effort is made to harvest seed. Moreover, cowpeas have not been grown very extensively for seed in late years, thus creating a high price which has restricted the use of the crop. The principal factors in making the cowpea an undesirable crop to grow in a commercial way for seed production are the uncertainty of a seed crop, the expense of harvesting, and the low yields generally obtained. However, the value of the crop for forage and soil improvement and the high price of seed make it highly desirable for every farmer to grow sufficient seed to supply at least his own needs. At high prices, most farmers do not feel that they can afford to buy seed for soil-improvement purposes. With a small acreage harvested each year for seed, a supply will always be available for farm use.

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[1] The culture and varieties of this crop have been discussed in another publication. (Morse, W. J., Cowpeas: Culture and varieties. U. S. Dept. Agr., Farmers' Bul. 1148. 1920.)

The demand for seed of well-known varieties has kept the prices in recent years so high as to make cowpea-seed production a profitable line of farming. Localities well suited to its production will find it highly profitable to grow seed on a large scale, especially if the best machinery for handling the crop is used.

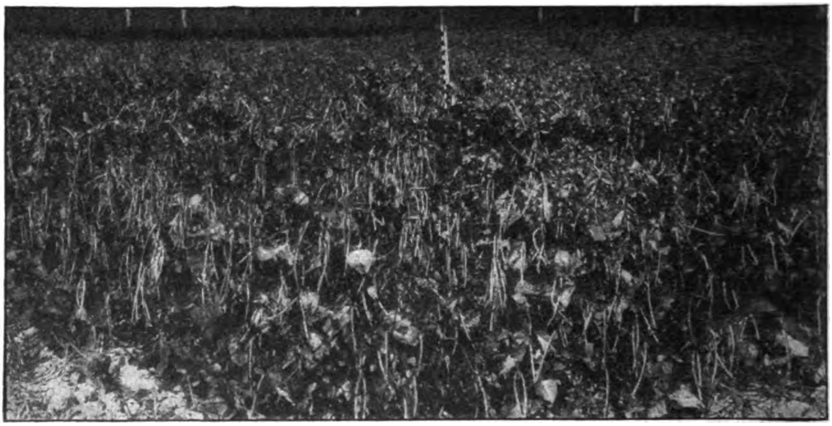

FIG. 1.—A field of the Victor cowpea grown for seed production.

Cowpea seed has a high feeding value, but it is not cheap enough to use for feed. It is a very palatable and nutritious human food and is quite generally used as such throughout the Southern States.

TIME OF HARVESTING.

Cowpeas ripen so unevenly that it is difficult to judge just what is the proper stage of maturity to cut for seed. With nearly all varieties except under certain conditions, as in the cowpea areas of California, blossoms and green and ripe pods occur at the same time, and this condition continues usually until frost.

In harvesting cowpeas for seed the vines should be allowed to mature a greater percentage of pods than when cut for hay. (Fig. 1.) In general, the crop should be harvested when one-half to two-thirds of the pods are matured. Although some loss will occur as a result of overripe pods shattering the seed, more seed will be obtained than if the crop is harvested before a large percentage of the pods are ripe.

METHODS OF HARVESTING.

Various methods of harvesting the cowpea for seed are employed in different sections of the cowpea region. Hand picking (fig. 2) is the most common way of saving the seed, although the most expensive and laborious, and is the only practical method when the crop is grown in corn. Small fields of cowpeas, grown alone for seed, are often hand picked, especially the edible sorts, as the Blackeye and White varieties. In this way the seed can be gathered as the pods ripen. The pods are gathered at a fixed price per hundred pounds, the rate depending on labor conditions, or the picker receives one-third to one-half of the total quantity gathered. When hand picked, the seed yield is much larger, is of a better quality, and a higher price is obtained. The pods are picked by hand into bags and stored. When thoroughly dry, the seeds are either beaten out with flails (fig. 3) or the pods are run through a pod huller. The seed is then cleaned by running it through a fanning mill.

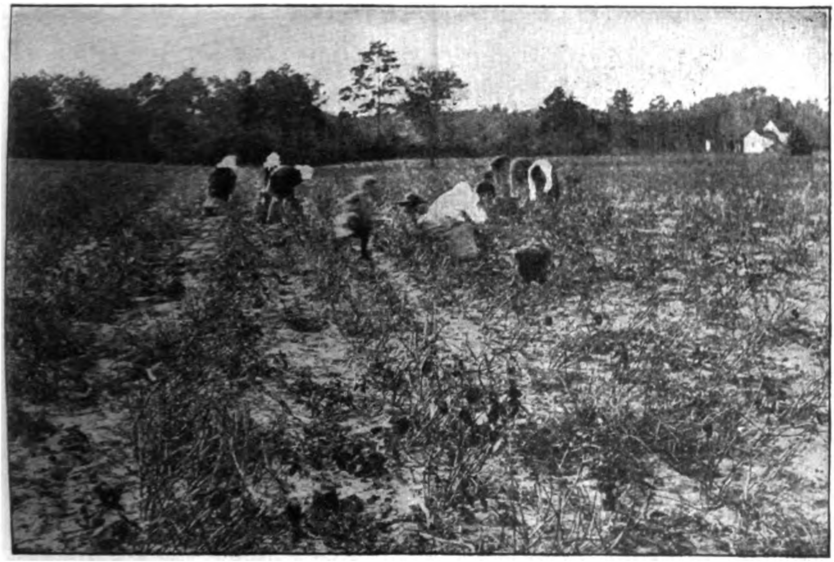

FIG. 2.—Harvesting cowpeas for seed by the hand-picking method.

Another method of harvesting by hand is to pull up the vines or to cut with a corn knife or sickle. The vines are placed in small shocks and left in the field until well cured. This method is slow and only practicable where the acreage is small.

When large fields are grown for seed production, various machines are used for cutting the vines. Some difficulty is experienced in harvesting cowpeas by machinery, due principally to the vining habit of the plant. The mowing machine is very generally used. The chief objection to this is the fact that the machine and horses have to pass over the crop while in the swath, which shatters the seed badly. This may be avoided, however, by attaching a bunching or windrowing attachment to the cutter bar of the mowing machine, which lifts the vines as they are cut and carries them to one side, out of the way of the next round. This method also leaves the plants in a more desirable condition for curing and handling.

The self-rake reaper (fig. 4) has given very satisfactory results, as the vines are placed in bunches of convenient size for handling and curing, out of the way of the machine and team.

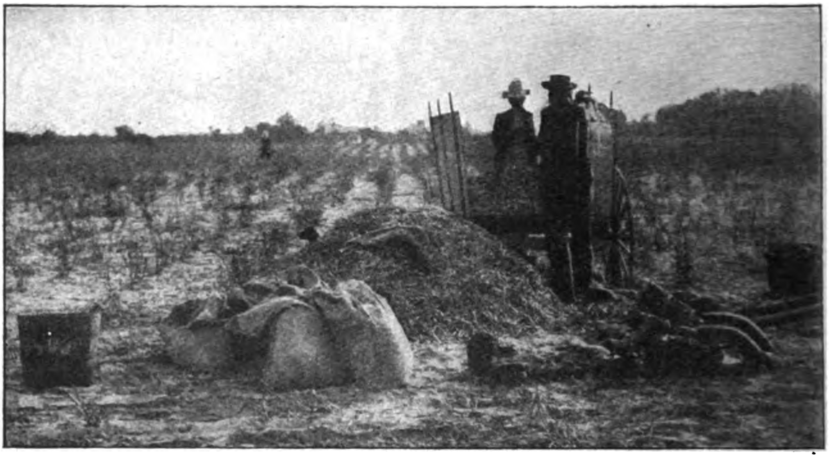

FIG. 3.—Flailing out cowpea seed, a method used to some extent in the Southern States.

Several types of bean and pea picking machines are on the market, but are not extensively used. These machines gather the pods from the vines in the fields. The crop must be planted in rows for the most successful application of the pea picker, and the entire plant must be mature and dry before the machine will do satisfactory work.

The bean harvester, of which several types commonly are employed in harvesting field beans, will work well with cowpeas planted in rows. The most successful of these harvesters are constructed so that the long knives run under the vines, cutting off the stems beneath the surface of the ground. In the Blackeye pea districts of California, a bean cutter, consisting of a pair of sharp knives about 3½ feet long and mounted on a sled from which they stand inward and slope backward at an angle of 60°, is the commonest method of harvesting. The sled straddles two rows and the knives are set to run about 2 inches beneath the surface of the soil, cutting the roots where they are soft and leaving the plants in one windrow.

When cut, the vines should be allowed to cure until thoroughly dry. The curing or drying may be done in the swath, cock, stack, or barn as desired, weather conditions largely determining the method to be employed. Although the amount of work required is greater, the hay or straw is of better quality if the curing or drying is done in the stack or barn. The belief is general that weevils will not affect the seed stored in the pods. Experience, however, shows that the damage from the weevil seems to be about as great to the seed in the pod as in the seed thrashed and stored.

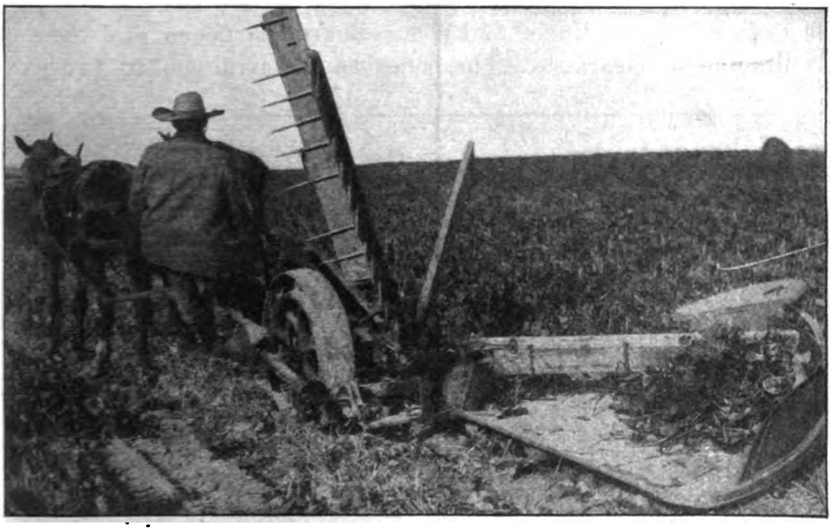

FIG. 4.—Harvesting cowpeas for seed with a self-rake reaper.

METHODS OF THRASHING.

The ordinary grain separator can be adjusted to thrash cowpeas successfully and is the machine most generally used. For the best results in thrashing cowpeas the essential point is to maintain a low and even speed of the cylinder, 300 to 400 revolutions per minute, while the speed of the rest of the machine should be maintained as for thrashing wheat or oats. Although satisfactory results are obtained with an ordinary separator, it is generally found that too many of the pods pass through unopened with the straw, the machine is easily choked by the tangled vines wrapping around the cylinder, and the percentage of cracked seed is usually large.

Several modifications of thrashing machines (fig. 5) have been devised for handling cowpeas. Many of these machines have adopted the use of two cylinders. The cylinders are adjusted to run at different speeds, the front one about 300 revolutions and the rear one about 450 revolutions to the minute. The employment of two cylinders results in a smaller percentage of unopened pods passing through with the straw, but in a somewhat larger percentage of cracked peas.

Another modification applied to machines with either one or two cylinders is the sharpening of the teeth on the concaves or on both the concaves and cylinders. The sharp teeth cut the vines and this prevents them from wrapping around the cylinder. Moreover, the power required is materially reduced and the percentage of cracked seed is decidedly less. The straw is finely chopped, thus being in excellent condition for feeding.

One of the most successful thrashers yet devised is that in which the teeth of both cylinder and concaves are sharpened and there is a minimum of clearance. The concaves are arranged in two sets, one of two rows and the other of three. The percentage of cracked seed is very small, the vines are finely chopped, and all of the seeds are released from the pods.

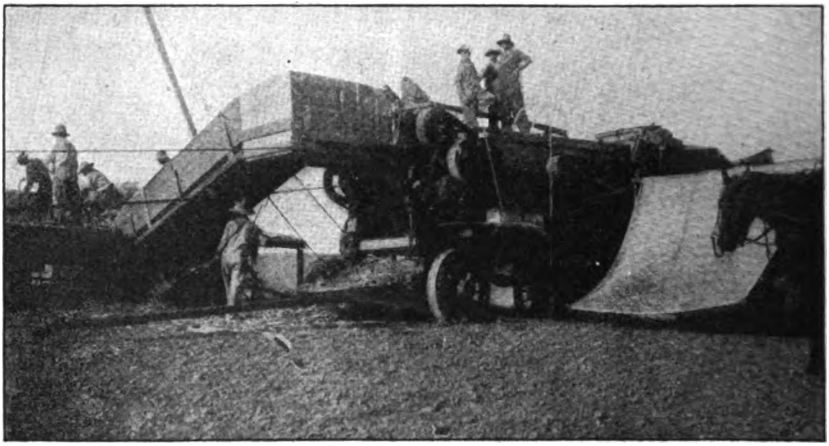

FIG. 5.—Thrashing seed in the Blackeye cowpea region of California.

In thrashing cowpeas it is necessary to have sufficient power to give a uniform speed to the separator. It is also essential that the cylinder be kept uniformly full in order to get the best results, as running empty increases the number of cracked seed.

STORAGE OF SEED.

Cowpea seed, if good, can be stored for a considerable length of time without much danger of loss of vitality, as shown in Table I. If the peas are sufficiently cured in the field, mow, or stack before thrashing, there is little danger of heating. However, seed not properly cured or stored quickly loses its vitality; consequently a germination test is always advisable.

Cowpea seed is subject to attack from insects, especially the cowpea weevil. There are usually some weevils in the seed when thrashed and placed in storage, and in a warm temperature they emerge and lay their eggs upon the other stored seed.

In the Southern States, on account of the injury to stored grain, it has been found desirable in many cases to place in cold storage the seed intended for planting. This is not very expensive and has been found to be a practicable way of preserving the seed.

Table I gives the results of germination tests with seeds of different varieties kept for 4, 7, and 10 years in a storeroom.

TABLE I.—*Germination of seed of standard varieties of cowpeas when stored for different periods.*

Variety.	Length of time seed was stored.			Variety.	Length of time seed was stored.		
	4 years.	7 years.	10 years.		4 years.	7 years.	10 years.
Whippoorwill........per cent..	96	93.5	79.5	Blackeye.............per cent..	22	3.5	0
New Era...................do....	73	61	18	Red Ripper..............do....	3.5	.5	0
Iron.......................do....	60.5	17.5	14.5	Groit......................do....	0	0	0
Clay.......................do....	38	8	1.5	Michigan Favorite........do....	0	0	0
Black......................do....	79	82	......	Extra Early Blackeye...do....	0	0	0
Taylor.....................do....	50	26.5	0				

Cowpea seed more than 2 years old ordinarily has lost much of its viability. Good viable seeds are uniformly bright colored, while seeds which have been exposed to moisture or are dead are duller and darker in color.

PROPORTION OF SEED TO HULLS.

In view of the fact that gathering the pods by hand is very generally practiced throughout the South, the proportion of seeds to pods is a matter of importance. The results obtained at different experiment stations indicate that the proportions of seed and hulls vary according to the variety and locality, as shown in Table II.

TABLE II.—*Weight of seed in 100 pounds of pods of standard varieties of cowpeas.*

Variety.	Alabama.	Arkansas.	Arlington Farm, Va.	Variety.	Alabama.	Arkansas.	Arlington Farm, Va.
Whippoorwill......pounds..	73	67.3	65.2	Red Ripper........pounds..	71	66	67
New Era..............do....	73	61.8	67.8	Taylor................do....	77	64.7	72
Groit.................do....	......	......	63.1	Large Blackeye.......do....	77	71.2	76.3
Brabham.............do....	......	......	69.2	Extra Early Blackeye do....	76	75	72.3
Iron..................do....	69	65.3	66	Black.................do....	76	73.2	71.7
Clay..................do....	67	58.3	63.5	California Blackeye...do....	......	......	73.3
Wonderful............do....	70	......	......	Early Buff............do....	......	......	73

FEEDING VALUE OF COWPEAS.

Cowpea seed is rarely obtainable at a price sufficiently low to justify its use as a feed. However, in thrashing, more or less seed may be broken, making it unfit for planting. Such seed ground and mixed with corn meal or other ground grain makes especially good feed for hogs and dairy cows. The composition of cowpea seed, as shown in Table III, indicates that it is of high feeding value in comparison with other feeding stuffs. The Alabama Agricultural Experiment Station[2] used cowpeas for fattening pigs with excellent results. In other feeding trials at the station mentioned cowpeas and corn were found practically equal in feeding value when fed separately, but a mixture of both proved more satisfactory than either alone. The Delaware Agricultural Experiment Station[3] reports that feeding weevil-eaten cowpea seed to 12 calves as a substitute for wheat bran at the same price per ton resulted in a saving of $7.20 per month. Excellent results have been obtained by feeding cowpea seed, either whole or cracked, to poultry.

TABLE III.—*Digestible nutrients of cowpea seed in comparison with those of other feedstuffs.*[a]

Feeding stuff.	Digestible nutrients in 100 pounds.				Feeding stuff.	Digestible nutrients in 100 pounds.			
	Protein.	Carbohydrates.	Fat.	Total.		Protein.	Carbohydrates.	Fat.	Total
Cowpea.......pounds..	19.4	54.5	1.1	76.4	Oats...........pounds..	9.7	52.1	3.8	70.4
Canada pea.......do....	19.0	55.8	.6	76.2	Wheat middlings.do....	15.7	52.8	4.3	78.2
Soy bean.........do....	30.7	22.8	14.4	85.9	Velvet bean......do....	18.1	50.8	5.3	80.8
Wheat bran......do....	12.5	41.6	3.0	60.9	Corn.............do....	7.7	66.1	4.6	84.2

[a] Henry, W. A., and Morrison, F. B. Feeds and feeding. Ed. 17, x, 691 p. Madison, Wis., 1917.

COWPEAS FOR HUMAN FOOD.

The cowpea is generally and favorably known as a table food in the Southern States.[4] Its limited use in the dietary of other parts of the United States is due chiefly to the fact that the culture of the cowpea has been confined principally to the South. No great effort has been made to create a general market, and competition with the navy or field beans in the North has not been developed. It is a most wholesome and nutritious foodstuff, from which a great variety of palatable as well as economical dishes can be made.

Cowpeas are used in three forms for human food—in the pod, shelled green, or shelled dried. In these forms they correspond, respectively, to string beans, shelled green peas, and dried navy beans and call for much the same methods of preparation for the table.

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[2] Duggar, J. F. Peanuts, cowpeas, and sweet potatoes as food for pigs. Ala. Agr. Exp. Sta. Bul. 93, p. 113–134. 1898.

[3] Neale, A. T. The development of a dairy herd. *In* Del. Agr. Exp. Sta., 12th Ann. Rept. [1899] 1900, p. 8–13. 1901.

[4] Langworthy, C. F., and Hunt, Caroline L. Use of corn, kafir, and cowpeas in the home. U. S. Dept. Agr., Farmers' Bul. 559, 12 p. 1913.

Undoubtedly the cowpea is of the greatest palatability from the time the pods begin to turn yellow until they begin to shrink in ripening. At this stage they are much larger than when fully mature and dry, are more easily cooked, and of better flavor. The color of the seed has much to do with the popularity of the cowpea for table use. The White varieties, such as the Conch, Cream, or Lady, and the Blackeye varieties, such as the California Blackeye and Large Blackeye, are preferred to the colored varieties.

YIELDS OF SEED.

The yield of seed, like that of hay, depends to a very large extent upon conditions of weather, soil, culture, and variety. In many sections the cowpea is rather an uncertain crop, as the yield of seed varies greatly from year to year. The seed yields of the most important commercial varieties reported by investigators at various agricultural experiment stations are shown in Table IV. In general, the figures show the average yields for a number of years and indicate the best seed-producing sorts.

TABLE IV.—*Yields of seed to the acre of the best varieties of cowpeas at different agricultural experiment stations.*

Variety.	Average yield of seed per acre (bushels).														
	Alabama.	Louisiana.	Arizona.	Arkansas.	Delaware.	Georgia.	Indiana.	Kansas.	Mississippi.	Missouri.	North Carolina.	Oklahoma.	South Carolina.	Texas.	Virginia.[1]
Black	21.1	13.0	.....	15.7	7.4	19.9	8.1	11.1	14.2	18.6	12.9	.....	13.0	20.3	20.0
Brabham	.....	.....	.....	.....	.....	11.1	.....	.....	29.1	.....	10.0	.....	.....	4.0	10.6
Clay	10.8	.....	.....	9.8	6.6	34.3	5.3	10.9	14.0	14.4	13.7	.....	13.3	2.1	.....
California Blackeye	.....	.....	.....	.....	.....	5.9	.....	4.1	.....	.....	.....	8.1	16.3	.....	16.3
Early Buff	.....	.....	2.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.6	19.7
Extra Early Blackeye	16.4	.....	.....	29.1	5.4	.....	14.2	9.9	.....	.....	9.2	.....	9.9	7.2	18.8
Groit	.....	.....	.....	.....	8.2	.....	.....	.....	26.8	14.8	17.3	2.2	.....	8.3	27.3
Iron	14.9	5.0	.....	.....	7.4	15.8	7.2	2.5	14.8	17.5	8.3	3.3	9.3	14.3	10.9
Large Blackeye	17.0	6.0	.....	23.6	5.6	31.3	.....	12.7	17.1	14.8	21.7	.....	21.7	17.0	26.3
Mirhigan Favorite	.....	.....	.....	.....	8.2	.....	19.3	11.2	.....	11.4	7.9	.....	.....	.....	19.8
Monetta	.....	.....	6.4	.....	.....	.....	.....	.....	.....	.....	10.9	.....	.....	1.3	13.2
New Era	22.0	18.7	.....	39.9	15.6	6.9	14.0	12.4	22.3	14.0	14.7	5.0	24.2	9.6	25.2
Red Ripper	19.3	4.5	.....	11.9	.....	27.7	.....	7.9	14.2	8.3	14.2	2.0	.....	2.7	.....
Taylor	23.6	.....	.....	19.9	4.9	11.3	.....	11.9	21.7	.....	10.6	2.4	11.5	9.7	18.6
Unknown	14.7	.....	.....	2.5	3.5	30.5	.....	.5	10.0	.....	4.4	1.5	.....	13.4	.....
Whippoorwill	12.4	12.7	.....	25.6	13.2	25.3	18.3	11.5	28.5	14.0	14.8	1.0	13.8	16.5	10.1

[1] Arlington Experiment Farm.

COWPEA STRAW.

The straw obtained from thrashing the cowpea for seed is a valuable feed for all kinds of stock. Although no data from feeding tests with this straw are available, farmers and liverymen who have used it claim that it is an excellent feed, some even preferring it to cowpea hay. No ill effects have been reported from its use. Table V gives the digestible nutrients of cowpea straw in comparison with those of the straw of other crops commonly used for feeding.

TABLE V.—*Digestible nutrients of cowpea straw compared with those of the straw of other important crops.*[1]

Kind of straw	Digestible nutrients in 100 pounds.				Kind of straw.	Digestible nutrients in 100 pounds.			
	Protein.	Carbohydrates.	Fat.	Total.		Protein.	Carbohydrates.	Fat.	Total.
Cowpea........pounds..	3.4	39.1	0.7	44.1	Wheat.........pounds..	0.7	35.1	0.5	36.9
Soy bean.........do....	2.8	38.5	1.0	43.5	Rice..............do....	.9	37.8	.3	42.8
Oat...............do....	1.0	42.6	.9	45.6	Barley............do....	.9	40.2	.6	42.5

[1] Henry, W. A., and Morrison, F. B. Feeds and Feeding. Ed. 17 x, 691 p. Madison, Wis., 1917.

COWPEAS FOR HAY.

If cut at the right stage of growth and properly handled, cowpeas make excellent hay of high feeding value. This hay is as valuable as that from other leguminous crops and is greatly relished by all farm animals. Throughout the Southern States cowpea hay has been extensively used and is the main dependence for hay on the plantations. Well-cured cowpea hay has proved satisfactory for work stock and for beef or milk production and has given good results when fed to poultry, hogs, and sheep. Cowpea hay is said to be better suited for feeding to cows than to horses. Partly on this account and partly because of the difficulty often experienced in properly curing the large growth of succulent vines and its coarseness and unevenness in quality, cowpea hay has but little standing in the city markets. When it becomes generally recognized that cowpea hay is a source of protein which can be raised on the farm, the quantity of high-priced concentrated feeds purchased for young animals or dairy cows will be very materially reduced.

TIME AND METHOD OF CUTTING.

As a rule cowpeas should not be cut for hay before the pods begin to turn yellow. The best quality is produced and the hay cures most readily if the vines are cut when most of the pods are full grown and a considerable number of them are mature. At that stage of growth none of the best hay varieties will have dropped their leaves and the plants will have practically attained their full growth. If cut before this stage, the vines are watery and difficult to cure, while if left too late before cutting there will be an unnecessary loss of leaves in handling and the stems will be tough and woody.

Under favorable conditions cowpeas after being cut for hay will sprout again from the base. Considerable pasturage or even a second crop of hay or seed is sometimes produced, especially in the Gulf coast region, if good moisture conditions follow the first cutting. Ordinarily, however, but a single cutting can be obtained.

The ordinary mowing machine (fig. 6) is the most practical machine for cutting cowpeas for hay. If an erect variety is grown, the entire plant can readily be saved. When grown on a small scale or between the rows of corn, cowpea hay is sometimes harvested by pulling the vines by hand and throwing them into small cocks to remain until cured. Scythes are also sometimes used in harvesting small areas.

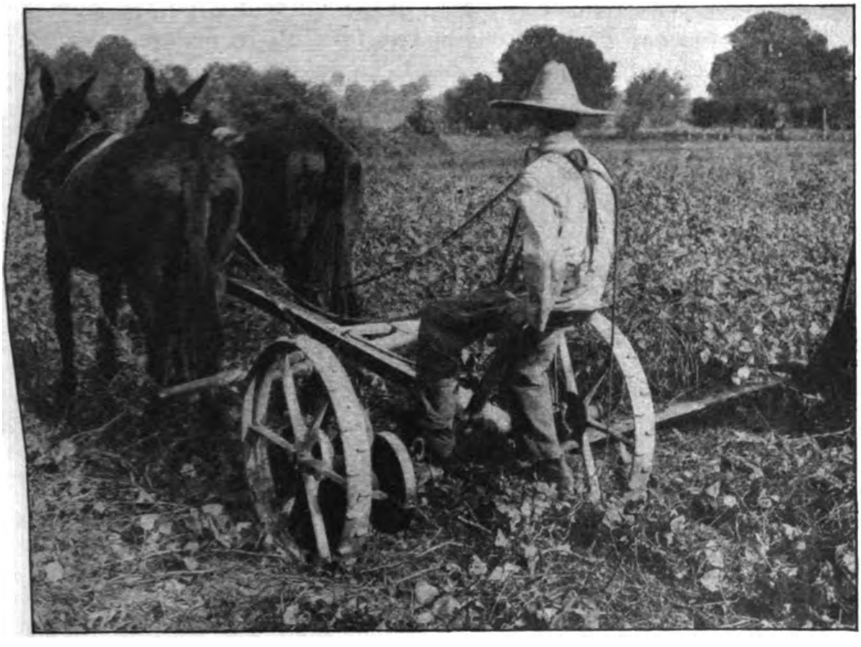

FIG. 6.—The mowing machine is the most practical implement in use for harvesting cowpea hay.

CURING COWPEA HAY.

Cowpea hay is somewhat difficult to cure if not properly handled, but with attention as to stage of growth and weather conditions little more trouble will be experienced in obtaining well-cured cowpea hay than red-clover or alfalfa hay. Numerous methods of curing are employed in various sections of the cowpea region, many of which are to be recommended.

The cutting should begin as soon as the dew is off and the indications are for favorable haymaking weather. The vines should be left in the swath until well wilted on top, but not until the leaves are dry and brittle. If the growth is very heavy the hay tedder should immediately follow the mower, so as to insure uniform drying conditions. The hay tedder may be also used to good advantage on the vines in the swath when the wilted stage of curing arrives, as it allows them to dry out more uniformly. The vines should then be raked into small windrows and left for one or two days. The tedder is also valuable for opening the windrows a half day or a day before cocking, or an ordinary rake can be used for turning the windrows over. The tedder should never be used except in the morning when the vines are damp; otherwise, too many leaves would be lost. After one or two days in the windrow, the hay should be thrown into small cocks of one or two forkfuls in order to permit circulation of the air. The cocks should be made as high and as narrow as possible and still permit them to stand well, and should be left until the vines are well cured, or from two to six days, depending on the conditions which have prevailed during the curing period. Then they should be opened a few hours before hauling or hauled without opening, according to the condition of the hay. A good rule to follow is that pea-vine hay is ready for stacking or putting in the barn when it is not possible to wring moisture out of the stems by twisting a handful with considerable force. Cowpea hay should be cured with as little exposure to the sun as possible. Too long exposure will cause the loss of the leaves, the most nutritious part of the plant.

If wet weather sets in directly after mowing, it is not advisable to handle the vines at all until after the rain. If the vines are fairly mature before cutting, a wet spell during haymaking, unless prolonged, is not of serious consequence. If, however, the vines are immature when cut, great difficulty is always experienced in unfavorable weather in curing the hay.

Many special devices are used more or less in curing cowpea hay. The most common of these is a pole, usually with crosspieces nailed at right angles, around which the vines are placed. Triangular frames (fig. 7), from 2 to 3 or more feet high, built of poles with crosspieces to hold them together, are used to some extent in the same manner. The object of these devices is to keep the vines from becoming too tightly packed and to have an air space in the center of the cock. These devices give excellent results in curing cowpeas, but, on account of the increased cost and labor involved, are not in general use.

Another method successfully practiced in some localities is that of placing the vines on poles or frames as soon as cut. The vines will form a good surface to shed water and should be left to stand two or three weeks, or until ready to stack.

The use of salt has been recommended by many successful growers. Although not essential, undoubtedly the hay is improved in palatability, and it may, in the case of hay not entirely cured, assist in preventing fermentation. About 8 quarts of salt are used to 1 ton of hay.

FEEDING VALUE OF THE HAY.

The feeding value of cowpea hay has long been recognized throughout the Southern States, it having been used extensively for all kinds of stock. Well-cured cowpea hay is fully as valuable a feed, pound for pound, as red-clover hay, and its value nearly equals that of alfalfa hay or wheat bran. It has given satisfactory results when fed alone to work stock and has been used successfully as a maintenance ration for horses, mules, cattle, and sheep, and even for hogs and poultry.

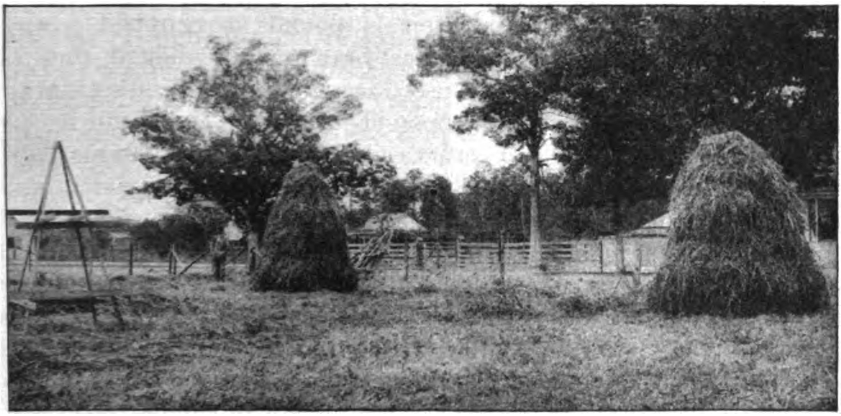

Fig. 7.—Cowpeas being cured on frames for hay.

The chief value of cowpea hay lies in its high percentage of digestible protein, which has been verified by numerous feeding tests. Table VI shows comparative analyses of important hay crops.

Table VI.—*Analyses of cowpea hay and other important hay crops.*[1]

Kind of hay.	Constituents (per cent).					
	Moisture.	Protein.	Fat.	Nitrogen-free extract.	Ash.	Fiber.
Cowpea	10.4	16.1	3.2	40.3	10.2	19.8
Soy bean	8.4	15.9	3.9	38.8	8.9	24.1
Alfalfa	8.7	15.9	2.7	36.8	8.8	27.1
Timothy	13.2	7.1	2.8	43.3	5.4	28.2
Red clover	12.9	13.6	3.4	39.1	6.9	24.1

[1] Average analyses, as reported by G. L. Bidwell, of the Bureau of Chemistry.

The Missouri Agricultural Experiment Station,[5] in comparing cowpea hay with timothy in wintering yearling steers, found that when fed with corn the substitution of cowpea hay for timothy hay more than doubled the gains. In another feeding test at the same station, comparing cowpea hay with clover hay and timothy hay for feeding steers, the steers made nearly 50 per cent better gain with cowpea hay than with timothy, and it was found that cowpea hay and red-clover hay had nearly the same feeding value. In a test at the North Carolina Agricultural Experiment Station[6] the rations fed for three months to two high-grade Percheron mares, used as a team and receiving the same care and shelter, differed only in the use of 10 pounds of cowpea hay for the one and the same quantity of wheat bran for the other. The horse fed on bran held its own in weight, while the one fed on cowpea hay gained a little.

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[5] Grantham, A. E. Cowpeas. Mo. Agr. Exp. Sta. Bul. 73, 60 p., illus. 1906.

The Tennessee Agricultural Experiment Station[7] reports that in the production of milk and butter 1¼ pounds of chopped cowpea hay is equivalent to 1 pound of wheat bran and 3 pounds of chopped cowpea hay to 1 pound of cottonseed meal. In beef production, the same station[8] found that 6 to 10 pounds of cowpea hay could be substituted for 3 to 5 pounds of cottonseed meal. At the Alabama Agricultural Experiment Station,[9] in feeding experiments with milk cows, results show that cowpea hay increased the yield of butter 11 per cent as compared with wheat bran, although more cowpea hay was consumed. The tests indicate that cowpea hay can be substituted for a part of the bran ration with satisfactory results. The Oklahoma Agricultural Experiment Station,[10] in feeding experiments with sheep, used four lots of 10 lambs each, the feeding period covering 20 weeks. The rations fed were as follows: (1) Alfalfa and cowpea hay, with corn meal; (2) corn stover and alfalfa hay, with corn meal and cottonseed meal, 3 to 1; and (3) prairie hay, with the last-mentioned grain mixture. The total gains for each lot ranged from 393 pounds on the prairie-hay ration to 521 pounds on the cowpea hay and corn-meal ration. Gain was most cheaply made on the cowpea-hay ration, and most expensively on the prairie-hay ration. In a continuation of previous work the West Virginia Agricultural Experiment Station[11] reports results of three tests with lambs, comparing cowpea hay with mixed timothy and clover hay, with and without shelled corn. The lambs receiving cowpea hay were fed each year at a profit, while those receiving the mixed hay were profitable only in one instance.

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[6] Burkett, C. W. Feeding farm horses and mules. N. C. Agr. Exp. Sta. Bul. 189, p. 99–127. 1903.

[7] Soule, A. M., and Barnes, S. E. The relative value of protein in cottonseed meal, cowpea hay, and wheat bran. Tenn. Agr. Exp. Sta. Bul., v. 15, no. 4, p. 143–163, illus. 1902.

[8] Soule, A. M., and Fain, J. R. Feeding native steers. Tenn. Agr. Exp. Sta. Bul., v. 15, no. 3, p. 111–140, illus. 1902.

[9] Duggar, J. F. Vetch, cowpeas, and soy bean hay as substitutes for wheat bran. Ala. Agr. Exp. Sta. Bul. 123, p. 51–72. 1903.

[10] McDonald, W. T., and Malone, J. S. Sheep feeding. Okla. Agr. Exp. Sta. Bul. 78, p. 57–64. 1908.

[11] Stewart, J. H., and Atwood, Horace. Lamb-feeding experiments. *In* W. Va. Agr. Exp. Sta. Bul. 90, p. 217–222. 1903.

As a winter feed for turkeys, ducks, geese, and chickens, cowpea hay, chopped fine and moistened, may be substituted for clover and alfalfa hay and for green feed with good results. Chopped cowpea hay mixed with corn meal and moistened has proved quite satisfactory for brood sows, and may be used as a substitute for roots or green feed in winter.

YIELDS OF COWPEA HAY.

As with other hay plants, the yields of the cowpea will depend to a large extent upon the soil, culture, weather conditions, and the variety. Under average conditions, the cowpea compares quite favorably in yield with other crops commonly grown for hay, while it ranks very high in yield of feeding value. The cowpea will yield from 1 to 2 tons of hay to the acre, and frequently, under very favorable conditions, much larger yields are secured. Yields of hay of important varieties of cowpeas at different experiment stations are shown in Table VII.

TABLE VII.—*Yields of hay obtained from important varieties of cowpeas at different agricultural experiment stations.*

Variety.	Average yields per acre (tons).													
	Alabama.	Arizona.	Arkansas.	Georgia.	Indiana.	Kansas.	Mississippi.	Missouri.	North Carolina.	Oklahoma.	South Carolina.	Texas.	Virginia.[1]	Florida.
Black	1.12	.....	2.03	0.81	1.76	2.23	2.27	1.74	1.32	1.56	0.81	.....	.....	.....
Brabham	.....	.....	.....	1.12	.....	.....	1.80	.....	1.29	2.20	1.12	1.75	1.89	1.26
Clay	1.42	0.56	2.88	.60	1.93	1.94	2.27	2.11	.97	1.36	.....	.....	.....	.....
Early Buff	.....	.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.78	1.48	.....
Early Red	.....	1.56	.....	.....	.....	.....	.....	.....	1.31	.....	.....	.....	1.54	.....
Extra Early Blackeye	.71	.....	1.06	.....	.....	2.17	.....	1.56	1.28	.....	.....	.....	.71	.....
Groit	1.23	.....	.....	.....	.....	.....	2.04	2.08	1.47	1.49	.....	1.38	1.90	.48
Iron	1.55	.....	.....	1.03	1.97	.....	1.98	1.47	1.35	1.66	1.08	.93	1.88	1.01
Large Blackeye	.....	.....	.....	.98	.....	.....	1.63	.....	1.25	.....	.98	.....	.....	.....
Michigan Favorite	.....	.....	.....	.....	1.68	2.10	.....	1.63	.....	.....	.....	.....	.....	.....
Monetta	.....	2.44	.....	.....	.....	.....	.....	.....	1.53	.....	.....	1.60	1.84	.....
New Era	1.15	.....	.65	.45	1.57	2.14	1.77	1.76	1.14	1.11	1.15	.....	1.69	.53
Red Ripper	1.86	.....	1.73	.93	.....	.....	2.21	1.88	1.07	1.70	1.86	1.38	.....	.66
Taylor	.....	.64	1.86	.70	.....	2.47	2.17	.....	1.26	1.74	.....	1.10	1.81	.....
Unknown	1.57	.....	2.46	.66	.....	.....	2.33	.....	1.88	2.14	1.55	.....	.....	1.08
Whippoorwill	1.36	.....	.91	.86	1.55	2.63	1.92	1.81	1.41	2.15	.86	.69	1.83	.92

[1] Arlington Experiment Farm.

COWPEAS FOR PASTURE.

The utilization of the cowpea as a strictly pasture plant is not considered the best farm practice, but under certain conditions it is advisable and quite profitable. The cowpea furnishes a pasture crop during a period of the year when such forage can be used to the best advantage. The small amount of work and the small cash outlay always associated with the grazing of stock commends the practice to the average farmer, and scarcity of labor often makes it necessary to pasture a crop whenever possible. Another advantage in pasturing cowpeas is that not only is the soil benefited by the growing of the cowpea but the waste vines and animal droppings are also left on the land. The soil, after cowpeas have been pastured, is in an excellent condition of productivity for the fall sowing of wheat.

The best time for turning the stock on cowpeas is when the crop has reached the stage of maturity considered best for hay—that is, when the first pods have matured. This practice, however, is not generally followed, as it is usual to gather at least a part of the seed. When cowpeas are grown in corn the grazing is deferred until the corn has been gathered. Cattle are usually turned on earlier than hogs or sheep, the hogs being pastured on the ripe seed. If stock are turned on when the plants have not attained full size, there is more waste from trampling. As with most green-pasture crops, there is danger of bloat when sheep or cattle are first turned on cowpeas, especially in wet weather. The danger from bloat, however, is far less than with alfalfa, and decreases as the cowpeas become more mature. If the seeds are sufficiently mature, frost will not greatly lessen the pasture value of the vines.

Practical experience shows that good results are obtained by pasturing cowpeas with any kind of live stock. The most common practice is to hog them down. For young hogs, cowpeas are an excellent feed, and but little grain is required to bring them to market weight. Usually hogs will feed on the mature pods first and leave the vines and leaves, especially when dry. After pasturing hogs on a field for some time, cattle or sheep may be used profitably to pasture off the leaves and vines which the hogs leave. Sheep may be used on cowpeas in the same way as hogs. When sown in corn, the stover blades and cowpea seed make a fine ration for fattening fall lambs and wethers. Dairy cows show the effect of such pasturage in a much-increased flow of milk.

At the Arkansas Agricultural Experiment Station[12] steers were fattened on cowpea pasture and cottonseed meal, making an average gain of 2 pounds a day for 90 days. As long as the cowpea vines were green and considerable seed was available, very little cottonseed meal was eaten. The cost of each pound of gain was only 2 cents for the cottonseed meal, thus showing the high value of the cowpea pasturage. The Oklahoma Agricultural Experiment Station[13] reports that cowpeas planted in July furnished two grazing periods for milk cows before frost and that the flow of milk was noticeably increased.

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[12] Bennet, R. L. An experiment in grazing a corn and cowpea field with steers. *In* Ark. Agr. Exp. Sta. Bul. 58, pp. 97–100. 1899.

[13] Burtis, F. C. Crop and forage notes. Okla. Agr. Exp. Sta. Bul. 48, 11 p. 1900.

In a feeding trial at the Alabama Agricultural Experiment Station[14] it was found that pigs fed on corn alone gained 0.36 pound daily, while hogs on cowpea pasture and corn gained 0.97 pound daily, consuming 36 per cent less corn for each pound gained. The same station[15] conducted a feeding experiment with pasturage for dairy cows, using an upland cornfield from which the ears had been removed and in which cowpeas had been drilled between the rows. The field was first pastured by three milk cows and later by three dry cows. The milk cows in the meantime received 3 pounds of cottonseed meal daily. On this pasturage the yield of milk was 15.8 per cent greater and the yield of butter 9.5 per cent greater than when the cows with the same grain feed ran on a good pasture of Bermuda grass, carpet grass, and lespedeza. In addition to the gain of milk and butter, the milk cows gained a total of 85 pounds during the 19 days and the dry cows a total of 53 pounds in 9 days.

COWPEAS FOR ENSILAGE.

The cowpea alone has not proved very successful as a silage crop. Most legumes give less satisfactory results when used alone for silage than when mixed with some other crop, such as corn or sorghum.

In addition to a high protein content the green vines of the cowpea contain a large proportion of water, producing a watery silage that keeps poorly and is not well relished by stock. Moreover, the vines form a tangled mass, which is difficult to cut, and without cutting the vines do not pack well, allow the air to enter, and cause the silage to mold.

The best silage is obtained when cowpeas are grown or mixed with corn or sorghum. Various methods are employed in growing and working in the silo the crops used in the mixed silage. The best results have been secured by planting cowpeas at the same time with the corn, using a cowpea attachment to the corn planter. Another common practice is to plant the seed alongside the corn rows at the second cultivation and sometimes at the last cultivation of the corn. In some sections of the South corn or sorghum and cowpeas are often sown in alternate rows.

For silage, cowpeas should be cut when the pods first begin to turn yellow. In many sections alternate rows of cowpeas and corn are put in the silo, but the most common method, perhaps, is one load of cowpeas to two or three loads of corn. This mixture is easily handled, packs quite satisfactorily, keeps well, and makes a superior quality of palatable silage. Although the vines may be put in the silo without cutting, they will pack much closer if run through a silage cutter. Much care should be taken to see that the silage is well distributed and well packed.

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[14] Duggar, J. F. Peanuts, cowpeas, and sweet potatoes as food for pigs. Ala. Agr. Exp. Sta. Bul. 93, p. 113–134. 1898.

[15] Duggar, J. F., and Clark, R. W. Feeding experiments with dairy cows. Ala. Agr. Exp. Sta. Bul. 114, p. 53–80. 1901.

When combined with either corn or sorghum, mixed silage has a greater feeding value than either corn or sorghum silage alone. As cowpeas are relatively high in protein, the mixed silage furnishes a better balanced ration. In testing the value of cowpea silage as a substitute for bran with milk cows, the Delaware Agricultural Experiment Station[16] found that, considered on the basis of milk and butter, the balance was in favor of cowpeas. The same station, in comparing cowpea silage for milk cows, found that 40 pounds of cowpea silage was very much superior to its own weight of corn silage, plus 1½ pounds of cottonseed meal. Table VIII compares the average composition of crops most generally utilized for ensilage.

TABLE VIII.—*Average composition of various silage crops.*[1]

Crop.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
Corn	79.1	1.4	1.7	6.0	11.0	0.8
Sorghum	76.1	1.1	.8	6.4	15.3	.3
Cowpea and sorghum	68.4	1.9	2.2	8.5	18.3	.7
Cowpea	79.3	2.9	2.7	6.0	7.6	1.5
Soy bean	74.2	2.8	4.1	9.7	6.9	2.2

[1] Henry, W. A., and Morrison, F. B. Feeds and feeding. Ed. 17, x, 691 p. Madison, Wis., 1917.

COWPEAS FOR SOILING.

Cowpeas can be utilized to good advantage as a soiling crop. With its high percentage of protein it is an excellent supplement to less nitrogenous crops, such as corn, sorghum, and millet. The wide variation in the maturity of the varieties makes it possible to have an abundance of green forage throughout the greater part of the summer and fall.

COWPEAS FOR SOIL IMPROVEMENT.

The cowpea has been used as a restorative crop more than any other leguminous crop, especially throughout the Southern States. It is so easily grown and has such a marked effect on the succeeding crops that its use should be greatly increased. Aside from increasing the productiveness of the soil, the cowpea also improves its general physical condition, making heavy clay soils more open and sandy soils more compact. The cowpea has the distinct advantage of making a good growth on soils that will not produce profitable yields of other legumes or cereals. It is an excellent green-manure crop for vineyards and orchards.

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[16] [Cowpea silage vs. bran for milch cows.] *In* Del. Agr. Exp. Sta. Bul. 26, p. 10–11. 1895.

Except on the poorer soils, results indicate that it is decidedly more profitable to utilize the cowpea as hay or pasture and then plow under the stubble than it is to plow under the entire crop. About 85 per cent of the fertilizing and soil-improving value of the cowpea is contained in the hay and about 15 per cent in the roots and stubble. Feeding experiments indicate that much of the fertilizing value of feeds is recovered in the manure. It is therefore possible to obtain the feeding value of the cowpea as hay or pasture and in returning the manure to the soil to save a large part of the fertilizing value, provided the manure is well handled. When the whole crop is plowed under, a more beneficial and lasting effect is obtained, but this advantage is not great enough to equal the feeding value of the cowpea.

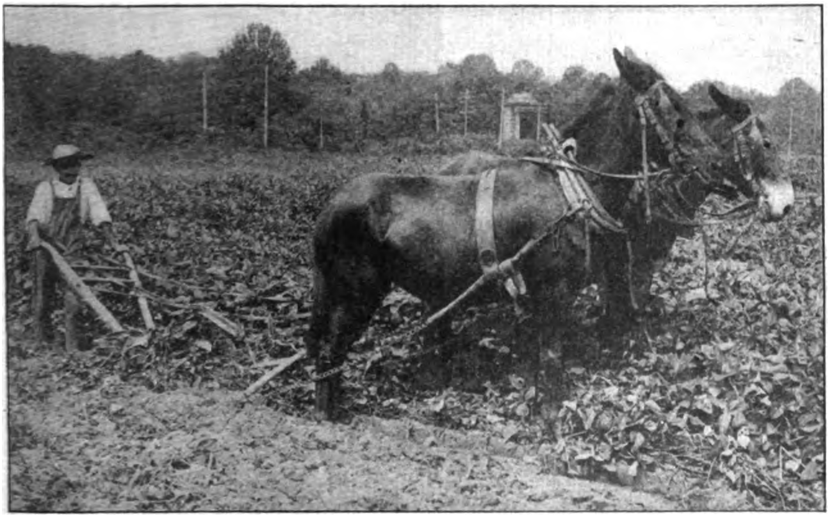

FIG. 8.—Plowing under cowpeas for green manuring.

Light or sandy soils that have been cropped for a long time and need humus receive greater benefit from plowing under the whole crop. (Fig. 8.) When, therefore, the improvement of the land is the sole object, the entire crop should be plowed under to obtain the greatest value. In utilizing the entire crop for soil improvement, it is best to plow it under when green before being killed by frost. The green plants decay more readily and are superior to dry plants in their fertilizing effect.

The results of analyses made by the North Carolina Agricultural Experiment Station[17] show that 1 ton of cowpea hay contains 47 pounds of nitrogen, 10 pounds of phosphoric acid, and 29 pounds of potash. Table IX gives the fertilizing materials in 100 pounds of dry substance of legumes commonly utilized for soil-improving purposes.

TABLE IX.—*Fertilizing constituents in 100 pounds of dry substance of the tops and roots of important legumes.*

Plant and part.	Nitrogen.	Phosphoric acid.	Potash.	Plant and part.	Nitrogen.	Phosphoric acid.	Potash.
Red clover:				Cowpea:			
Tops..........pounds..	2.35	0.58	2.14	Tops..........pounds..	1.96	0.51	1.93
Roots............do....	2.74	.84	.82	Roots............do....	1.18	.55	.93
Alfalfa:				Soy bean:			
Tops............do....	2.30	.54	1.52	Tops............do....	2.18	.61	1.68
Roots............do....	2.04	.43	.48	Roots............do....	1.05	.34	.67
Crimson clover:				Velvet bean..........do....	2.51	.53	3.84
Tops............do....	2.13	.62	1.35	Common vetch:			
Roots............do....	1.50	.47	1.02	Tops............do....	2.99	.71	2.68
				Roots............do....	2.19	.79	1.18

Numerous experiments with the cowpea for soil-improving purposes demonstrate its beneficial effect upon succeeding crops, as shown by the increased yields obtained of corn, cotton, sorghum, and small grains. At the Alabama Agricultural Experiment Station[18] the increased yield of the following crops, showing the benefits obtained by plowing under the cowpea vines rather than taking the crop off for hay, was as follows: Corn, 49 per cent; sorghum, 9 per cent; cotton, 40 per cent. At the Missouri Agricultural Experiment Station[19] an increase in yield of 63 per cent with oats and 49 per cent with wheat following cowpeas as a catch crop was secured. The Arkansas Agricultural Experiment Station,[20] in tests covering four years with wheat, reports an average increase in yield of 25 per cent from plowing under cowpea stubble in the fall, 39 per cent from plowing under cowpea vines, and 42 per cent when cowpeas were grown each year as a catch crop between the wheat crops, only the stubble of the peas being turned under. At the same station[21] a crop of cowpeas on light sandy soil grown after harvesting rye and potatoes increased the following wheat crop 30 per cent. Wheat grown continuously on the same land for three years and each crop preceded by a crop of cowpeas gave an increased yield of 46.7 per cent, as compared with breaking the wheat stubble and not sowing cowpeas. The Georgia Agricultural Experiment Station[22] conducted an experiment with cowpeas followed by cotton in order to determine whether it would be more profitable to turn under the vines as green manure, to harvest as hay, or to pick the pods and plow under the vines. The results obtained indicated that the effects upon the subsequent crops of cotton were almost identical, being, however, slightly in favor of turning under the vines green. When, however, the value of the seed and the hay is taken into consideration, the experiments show that it is much more profitable to save the cowpeas as hay or as seed, and that either of these methods is more economical than the practice of turning under the entire crop.

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[17] Kilgore, B. W., Williams, C. B., MacNider, G. M., and Meacham, F. T. The culture of the cowpea. Bul. N. C. Dept. Agr., v. 31, no. 6, p. 70, illus. 1910.

[18] Duggar, J. F. The cowpea and the velvet bean as fertilizers. Ala. Agr. Exp. Sta. Bul. 120, p. 121–179, 3 figs. 1902.

[19] Grantham, A. E. Cowpeas. Mo. Agr. Exp. Sta. Bul. 73, 60 p., illus. 1906.

[20] Newman, C. L. Cowpeas: Fertilizing value. Ark. Agr. Exp. Sta. Bul. 77, p. 12–22. 1903.

[21] Newman, C. L. Wheat experiments. Ark. Agr. Exp. Sta. Bul. 62, p. 17–34. 1900.

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[22] Redding, R. J. Green manuring with cowpeas. *In* Ga. Agr. Exp. Sta. Bul. 27, p. 207-209. 1894.

FARMERS' BULLETIN 1154
UNITED STATES DEPARTMENT OF AGRICULTURE

A1.9:1154

·ASPEN· BORER

·AND·HOW·TO· ·CONTROL·IT·

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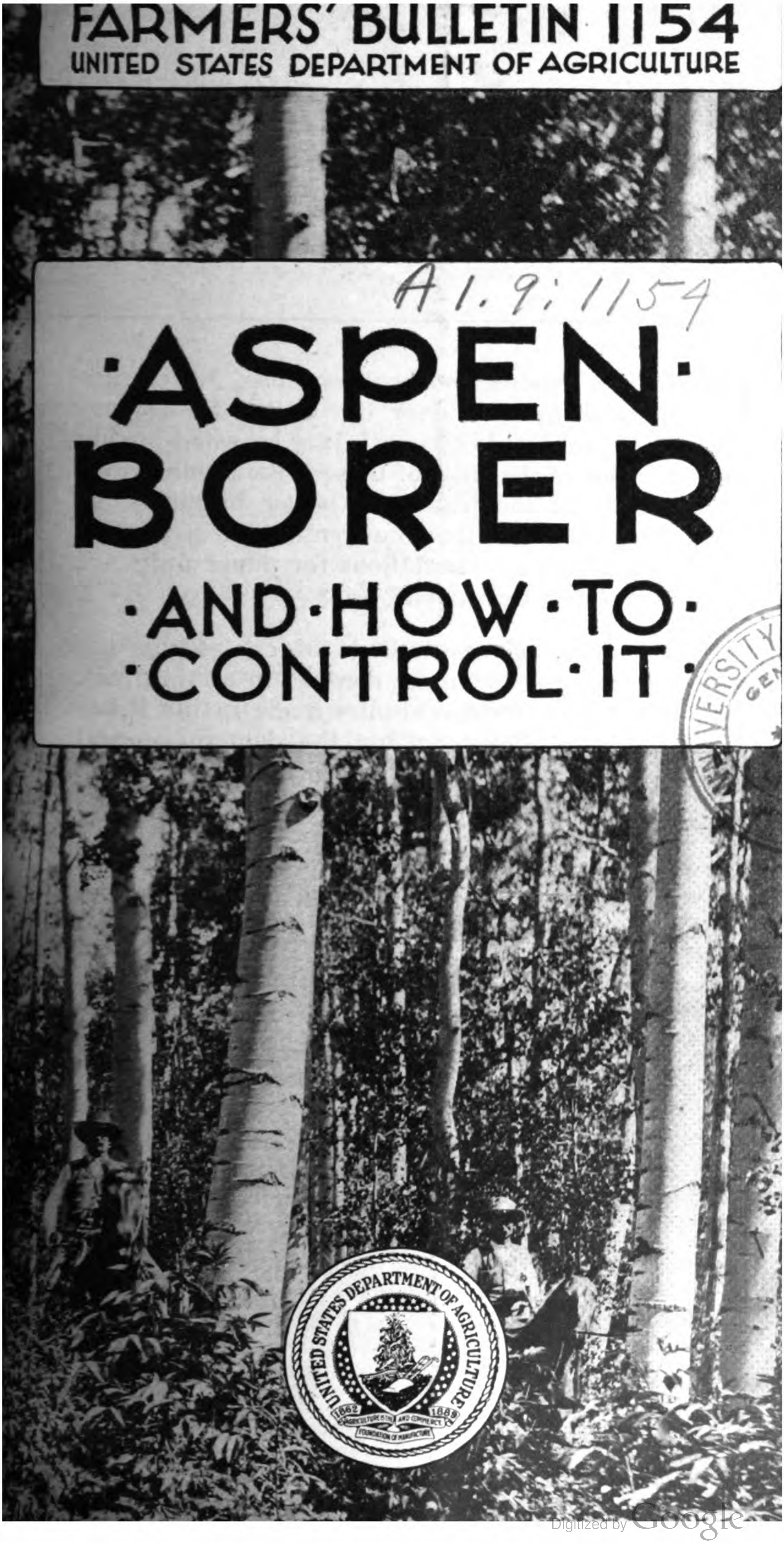

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POPLARS, aspens, and cottonwoods, which are widely distributed over the United States, are everywhere subject to serious injury by wood-boring insects. One of the chief of these is the aspen borer, which feeds in the trunks or larger branches, so weakening the wood that the tree is readily broken off by windstorms. Plantations for paper pulp are often completely destroyed.

This bulletin gives methods of controlling the aspen borer or reducing its damage to a minimum. It is based on extensive studies made in the Pikes Peak region of Colorado, but the data in general apply to all regions of the United States where the poplars are native. The introduced Lombardy poplar is very seldom injured, but the commercial cottonwood of the Mississippi Valley seems to be the only native species of poplar which is at all immune to the attack of this insect.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. October, 1920

THE ASPEN BORER[1] AND HOW TO CONTROL IT.

By GEORGE HOFER,
Entomological Ranger, Forest Insect Investigations.

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TREES ATTACKED BY THE ASPEN BORER.

EXTENSIVE deadenings in aspen trees, due primarily to the work of larvæ of woodboring beetles, occur throughout the Pikes Peak region of Colorado. The most common and widely distributed insect causing this injury is the aspen borer;[1] but at higher elevations and attacking only the base of the tree another roundheaded borer[2] plays an important part, causing a large percentage of windfalls.

Aspen shade trees are equally susceptible to injury by the aspen borer and are frequently killed or so riddled that they break off in the wind.

Among the native or introduced species of poplars[3] growing in this region none is immune from the ravages of the borer. A very large percentage of the various species of poplar in Colorado Springs, Colo., and adjacent city parks, together with those in the forests of this region, are affected by this insect.

The heartwood of trees which are repeatedly attacked becomes honeycombed, causing dead limbs and tops which are easily broken off by the wind, finally resulting in the death of the trees.

Aspen and poplars generally are looked upon as short-lived trees. This is true in a measure, but on Cheyenne Mountain, in Colorado, at an elevation of 9,000 feet, the writer recorded over 75 aspen trees, growing in mixture with Douglas fir and Engelmann spruce, that had attained a size of from 15 to 23 inches in diameter and from 70 to

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[1] *Saperda calcarata* Say.

[2] *Xylotrechus obliteratus* Lec.

[3] *Populus deltoides* (common cottonwood); *P. angustifolia* (narrowleaf cottonwood); *P. acuminata* (lanceleaf cottonwood); *P. fremontii* (Fremont cottonwood); *P. occidentalis* (western cottonwood); *P. nigra* var. *italica* (Lombardy poplar).

100 feet in height, with clean, sound trunks without a limb for 50 feet. These trees are from 65 to 100 years of age. (Figs. 1 and 2.)

The common aspen[4] comes up from seed scattered broadcast by the wind, and is an exceedingly valuable cover for watersheds and areas devastated by fire. It acts as a nurse to conifers which succeed it. The wood is used for fruit boxes, fence posts, and poles, and, when sound and free from insect work, for props and cribbing in coal mines. Of late years it is being used to a great extent for cabins and summer homes. (Fig. 3.)

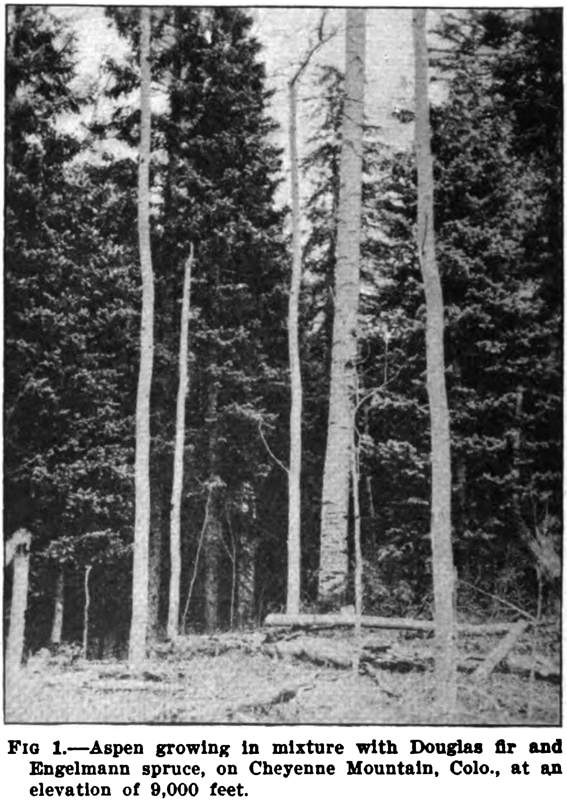

FIG 1.—Aspen growing in mixture with Douglas fir and Engelmann spruce, on Cheyenne Mountain, Colo., at an elevation of 9,000 feet.

The wood of the poplars is one of the materials used for pulp making. The trees are largely planted for shade and ornament, for windbreaks, and to hold the banks of streams.

CHARACTER AND EXTENT OF INJURIES.

The primary work of the aspen borer begins with an oblong scar made by the adult in the bark of living, healthy, and injured trees, in which the eggs are deposited, as shown in figure 4. The tiny grub or larva on hatching from the egg at once begins its destructive work by feeding and mining between the bark and wood, in which it remains for from 90 to 100 days. It then enters the sap and heartwood, where it excavates an oval-shaped longitudinal gallery 6 to 14 inches in length, as shown in figure 5.

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[4] *Populus tremuloides.*

The egg scars, whether the eggs hatch or not, are favorite places for entrance of other wood-boring insects and for fungi which hasten the death of such trees.

Throughout the forests of the Pikes Peak region many trees have died during the last 25 years. The old standing dead trees and those which have fallen bear evidence of the primary attack of the aspen borer in the conspicuous large scars, exit holes, and deformed trunks. (Fig. 6.)

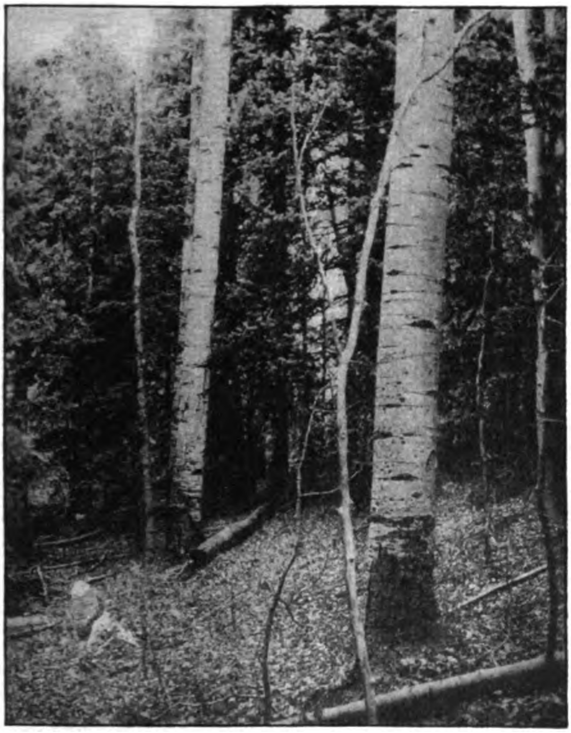

FIG. 2.—On Cheyenne Mountain, Colo., aspen which have attained a size of from 15 to 23 inches in diameter and from 70 to 100 feet in height.

In some localities the standing dead, fallen, and dying trees exceed 50 per cent of the total stand. A count made on an area of about 2 acres near Wade, on Cheyenne Mountain, Colo., in an even-aged stand of aspen gives the following figures:

Total number of trees	667
Number of living trees	260
Number of dying trees	34
Number of dead trees	340
Number of infested trees	33

Deformed trees, 40 per cent of total.

Trees of from 2 inches up to the largest diameter are attacked by this borer. The large trees are frequently attacked close to the limbs, while smaller trees are attacked from the base up.

One of the characteristic features of the injury caused by this insect is that it is concentrated on trees that have been previously injured. In every clump of aspens trees heavily infested, or what may be called "brood trees," can be found. This feature tends to limit the destruction by this borer by confining it to such trees, and at the same time it destroys many of the insects, in that these brood trees are frequently broken off by the wind or attacked by a fungus and a large percentage of the borers within fail to mature.

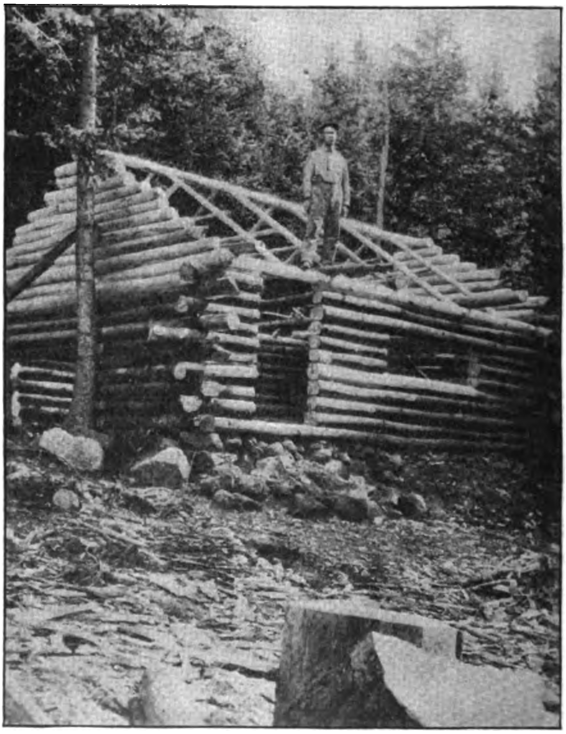

FIG. 3.—A summer home on Cheyenne Mountain, Colo., being constructed from aspen logs. These trees were cut within a radius of 200 yards of the structure. Elevation at this point, 9,000 feet.

One of the chief causes of the rapid deterioration and death of trees attacked by this insect is a wood rot[5] or fungus which follows the work of the borer and destroys the heartwood. Following the opening made through the bark this fungus rapidly penetrates and destroys the heartwood, and so weakens the tree that it is broken off by the wind. The development of this disease is often so rapid that it envelops and destroys the borer larva before it matures.

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[5] *Fomes igniarius.*

DISTRIBUTION.

The aspen borer is found in all parts of the country, its distribution coinciding with that of the poplar.

SEASONAL HISTORY AND HABITS.

Normally this species has but one generation in three years. During the latter part of July and during August the adult female beetle gnaws in the bark an oblong scar, which slopes toward the center, penetrating the cambium or inner bark of the tree. Beneath the bark in this scar she deposits one or two eggs (fig. 4), which hatch into larvæ or grubs in from 20 to 25 days. Upon hatching, the young larva mines beneath the bark, remaining there over winter, and entering the sapwood and heartwood the following spring, where it is active until May or June of the second year following the egg laying. During this time the gallery is enlarged and an opening is maintained through the bark at the place where the egg was laid, and through this boring dust is expelled during the feeding period of the larva. The accumulation of these piles of fibrous frass at the base of the trees is one of the most characteristic features indicating the presence of the borer. On reaching full growth the grub (fig. 7) excavates the pupal cell near the lower end of the larval mine and remains inactive in this cell (fig. 5) until the following spring. It then pupates and remains as a pupa (fig. 8) 25 to 30 days before transforming to the adult. During the latter part of July[6] or during August of the third year the adult emerges through the hole which the larva used for expelling the frass.

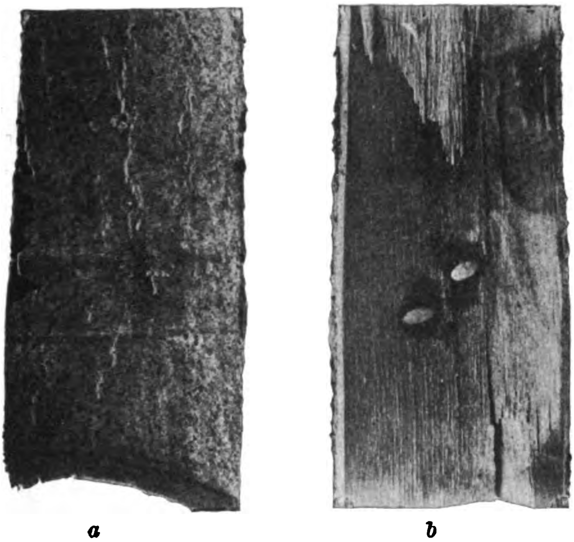

FIG. 4.—Aspen borer: *a*, Egg scar on living aspen trunk; *b*, bark removed to show eggs.

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[6] In the eastern United States, at an elevation of 500 feet, the beetles emerge from four to six weeks earlier.—F. C. C.

DESCRIPTION.

The adult (fig. 9) is an elongate, robust, grayish-green beetle, measuring from 21 to 30 mm. (about an inch) in length, and having faint yellowish spots on the wing covers. The antennæ or horns are very long, those of the female being about the length of the body, and those of the male even longer.

The larva is an elongate, cylindrical, footless grub of a whitish or yellowish white color. When full grown it measures from 30 to 35 mm. (about 1¼ inches) in length. It can be distinguished from all other wood borers in the trunk or large branches of poplars by the fact that it has the sides of the head parallel and the upper and lower surfaces of the body covered with fine horny points. On the first segment above, these are larger and curve backward. Two dark oblique lines are present on this segment in related species of poplar borers, but never on this insect.

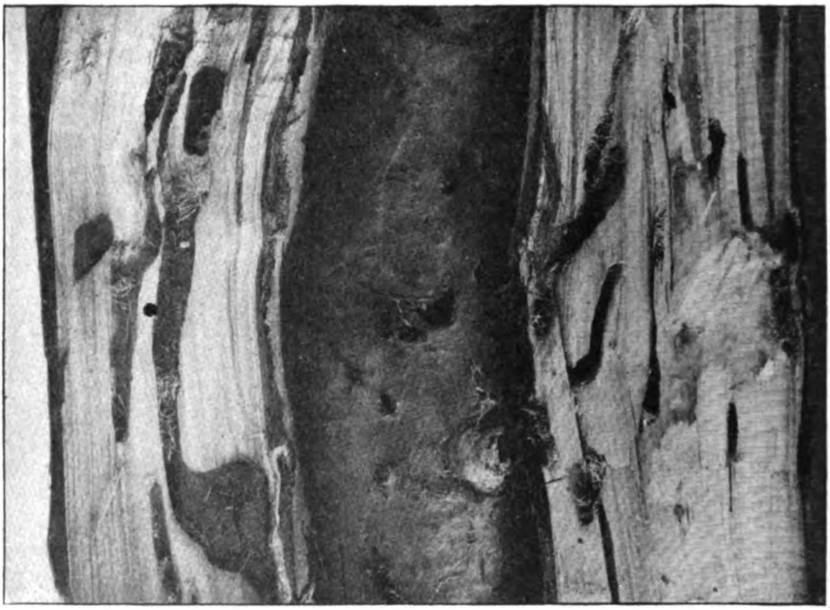

FIG. 5.—Split sections of aspens showing larval mines and pupal cells of the aspen borer, and the character of the frass. The smaller holes on the bark section are exudation pores from which frass is expelled by the larvæ.

The pupa, or intermediate stage between the larva and adult, has the same general form as the adult, but with its wings and legs folded along the side of the body. It is of a whitish color and the upper surface is provided with small horny spines.

NATURAL ENEMIES.

A tiny, wasplike, four-winged parasite which attacks the eggs of the borer has been reared and found very destructive to them.

Counts made on several areas show an average of about 25 per cent of the borer eggs destroyed by this insect.

Two-winged flies parasitic on the borer grubs were found to destroy 5 per cent of them; predacious insects and birds, less than 1 per cent. Fungous disease destroys 2 per cent of the mature larvæ, pupæ, and immature adults. The total annual mortality of the borer from these causes is from 30 to 38 per cent.

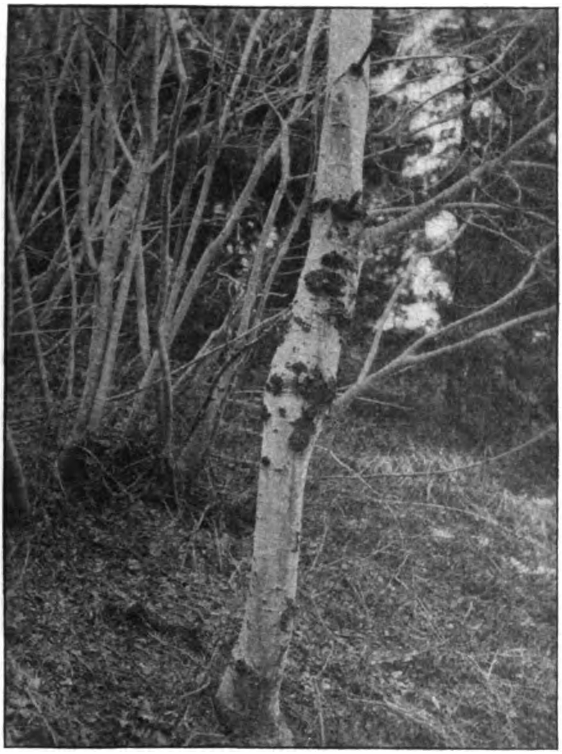

FIG. 6.—Living aspen, Cheyenne Mountain, Colo., altitude 7,000 feet. This tree is infested by 2 and 3 year old larvæ of the aspen borer. The swelling on the main trunk are the result of the work of these larvæ.

ASSOCIATED INSECTS AND DISEASE.

Generally associated with the injury of the aspen borer, there are the following insects and a fungous disease which more or less hasten the deterioration of the trees.

The bronze birch borer[7] attacks healthy, injured, and dying trees; it precedes and follows the attack of the aspen borer and may cause the death of the tree.

A flat-headed borer[8] deposits its eggs in the egg scars of the aspen borer, and in ax marks and bruises, and extends the damage in the heartwood.

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[7] *Agrilus anxius* Gory.

[8] *Poecilonota cyanipes* Say.

Another flat-headed borer[9] attacks injured and dying trees. It deposits eggs in old egg scars made by the aspen borer and in other injuries, and it bores into the heartwood.

A large moth[10] which attacks the poplar and deposits its eggs in the borer egg scars is most frequently found in trees infested by poplar borers. Its altitudinal range is the same as that of the borer, none having been found above 9,000 feet.

A pinhole borer[11] attacks injured and dying trees in which the sap has begun to sour. It follows the attack of the aspen borer and is found also in trees otherwise injured.

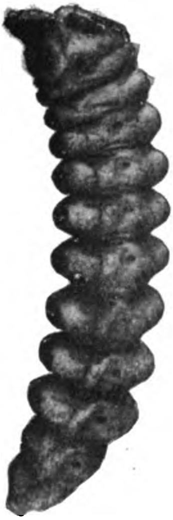

FIG. 7.—Side view of larva of the aspen borer.

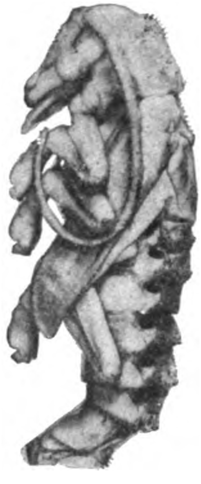

FIG. 8.—Side view of pupa of the aspen borer.

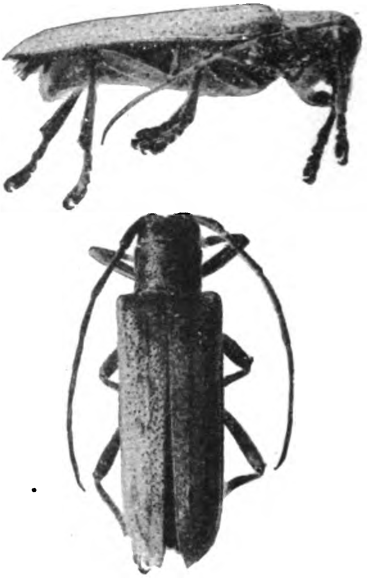

FIG. 9.—Aspen borer: Adult female, from side and from above.

A roundheaded borer[12] which occurs at higher altitudes than the poplar borer is the chief depredator in the aspen. Large areas have been denuded as the result of its work.

A heart rot,[13] causing much deterioration and decay in aspen, follows the attack of the aspen borer and other wood-boring insects, gaining entrance through the wounds made by them. It is present in nearly all trees attacked by the aspen borer.

CONDITION OF TREES ATTACKED.

Living, healthy, and injured trees are attacked by the aspen borer. Dead trees are never attacked. A strong preference is shown for trees which have partially succumbed to former attacks.

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[9] *Dicerca prolongata* Lec.

[10] *Cossus* sp.

[11] *Xyloterus* sp.

[12] *Xylotrechus obliteratus* Lec.

[13] *Fomes igniarius.*

SITUATION AND CONDITIONS FAVORABLE FOR ATTACK.

Trees on dry, rocky slopes appear to be more subject to attack than those on less exposed situations. Along the low, moist creek beds and mountain meadows the attack is not as severe as on drier slopes.

Infestation is most prevalent between altitudes of 6,500 and 8,000 feet. It has not been found to occur above 9,000 feet.[14]

CONTROL MEASURES.

Control experiments carried on from 1914 to 1917 in various localities and upon various clumps of aspen have shown that two methods are practicable and that the insect can be controlled if not entirely eliminated by either of them. The two methods recommended are the cutting of "brood trees" and the application of creosote or carbolineum.

"Brood trees" are those which are attacked for a number of years in succession and contain two or more generations of the aspen borer. These so-called "brood trees" can be readily distinguished from the healthy trees and those injured by other causes by the deformed main trunks, dead tops, limbs, and the brownish liquid and frass exuding from the egg scars during May and June each year, at which time the larvæ are active, extending and enlarging their galleries. As aspen usually grows in clumps, the main centers of infestation can be readily located.

First, locate a clump of aspen and determine the extent of the infestation, then with a sharp ax cut down the "brood trees." These can be laid in compact piles and burned or the main trunks split and exposed to the sun, which will dry out the wood enough to kill the brood. One man with a sharp ax can cut and treat 50 or more of these trees in a working day, as aspen as a rule is of small diameter.

Where it is essential or desirable to preserve the trees, the painting of the egg scars with carbolineum has proved a successful method of control, though not as effective or practicable in large and remote forested areas. On private lands and city parks, where poplars are valued for their shade and ornament, this remedy can be used to advantage.

Creosote should be applied to the egg scars with a 2-inch brush. It is important that this work be done thoroughly. October is the time to apply the creosote, after the adult beetles have deposited their eggs and most of these have hatched into tiny larvæ or borers.

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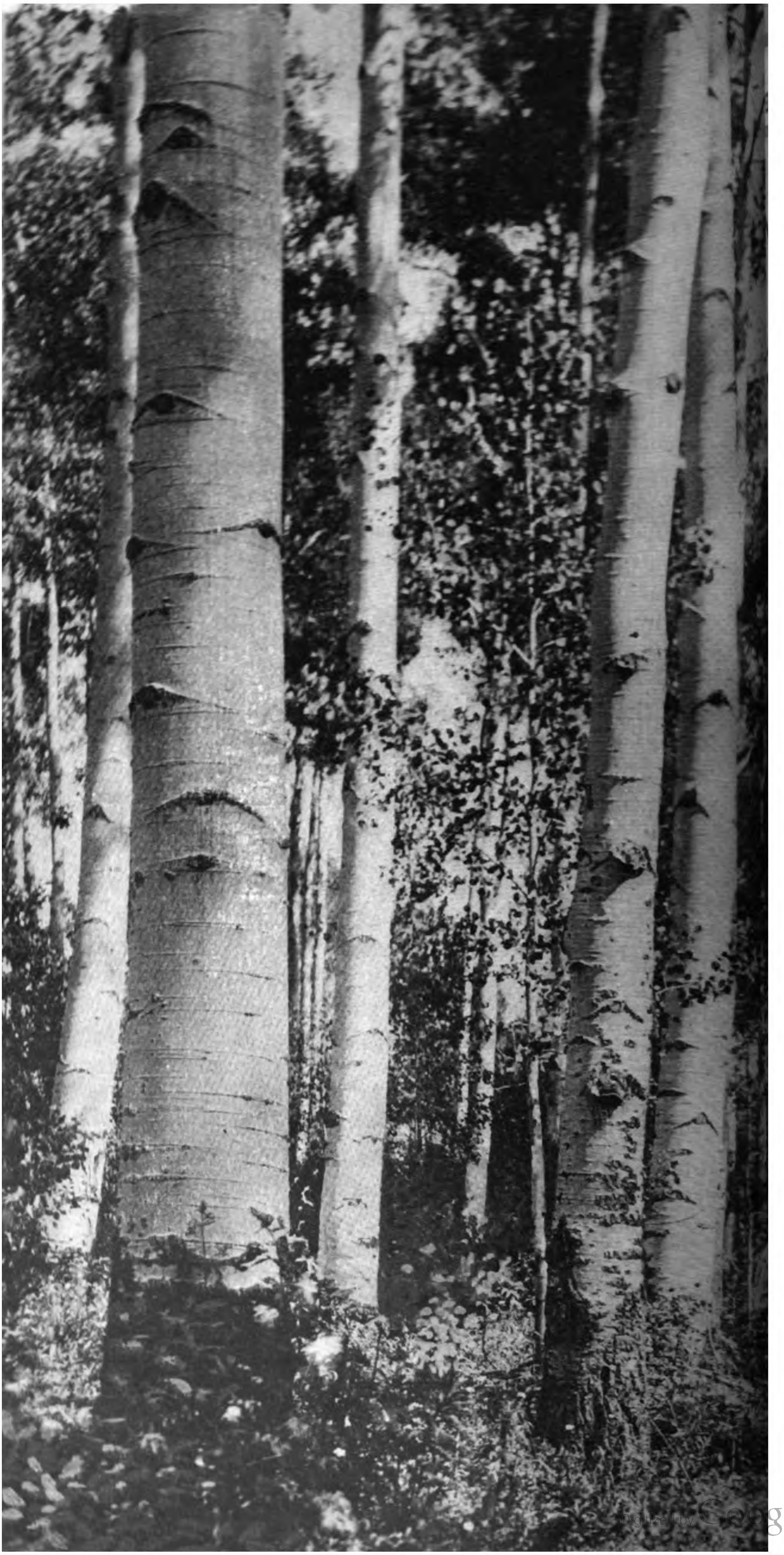
[14] In some sections of the country injury occurs down to sea level.—F. C. C.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920



FARMERS' BULLETIN 1155
UNITED STATES DEPARTMENT OF AGRICULTURE

DISEASES OF SHEEP

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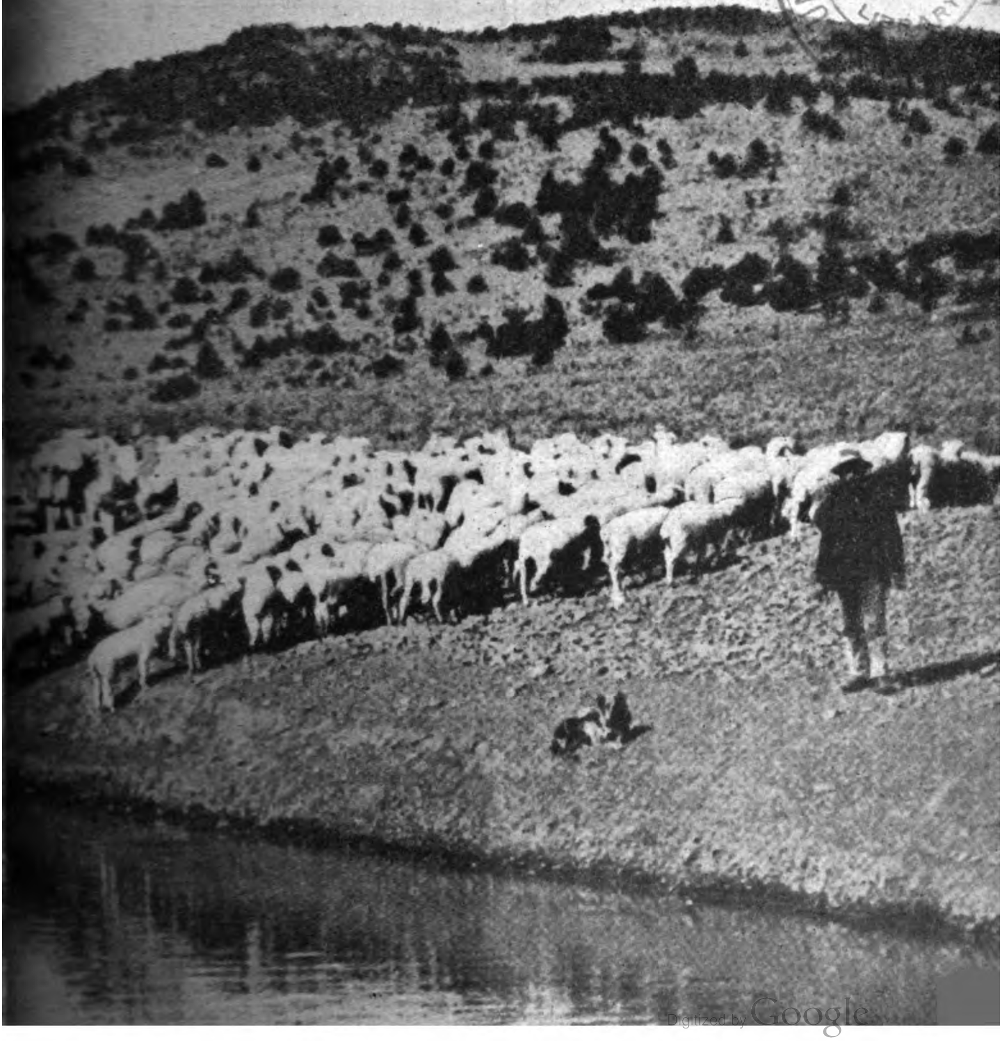

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Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief
Washington, D. C. March, 1921

DISEASES OF SHEEP.

BERNARD A. GALLAGHER, *Pathological Division.*

INFECTIOUS DISEASES.

ANTHRAX.

(Charbon, splenetic fever, malignant pustule, woolsorter's disease.)

ANTHRAX is a rapidly fatal, infectious febrile disease. In sheep it usually takes the acute form, but may be subacute.

Cause.—The disease is caused by the *Bacillus anthracis*, an organism of microscopic size.

Anthrax is contracted through feeding, through wounds exposed to infected soil, and through the contamination of wounds by flies which have fed on carcasses of animals that have died of anthrax or on discharges from diseased animals.

Symptoms.—In sheep the disease usually runs a rapid course, especially in the first animals affected. Apparently healthy animals suddenly develop weakness of the legs and difficult breathing. They fall to the ground, move convulsively, and may die in a few minutes or within an hour. Where death is less sudden, periods of stupor alternate with convulsions, the mucous membranes of the nostrils and mouth become bluish, the temperature is highly elevated, and bloody discharges may issue from the mouth, nostrils, or anus.

Post-mortem appearance.—The carcass decomposes and bloats rapidly. Bloody, frothy discharges are found around the natural openings of the body. Yellow, jellylike deposits and hemorrhagic areas are present beneath the skin. The blood does not clot and is tarlike in appearance. The spleen is greatly enlarged, its pulp softened or fluid and dark red or chocolate in color. The intestines and other internal organs are congested or hemorrhagic. The intestinal contents are bloody and the urine may be bloodstained; bloodstained fluid is found in the abdominal and lung cavities. Yellowish, jellylike deposits are observed beneath the serous membranes of the organs. The lungs show congestion and fluid infiltration.

Diagnosis.—Anthrax is distinguished from other diseases of sheep by the greatly enlarged, dark-colored, softened spleen; the uncoagulated, tarry blood; the jellylike deposits beneath the skin and in the viscera, and by the hemorrhagic condition of the intestines. In hemorrhagic septicemia, which most closely resembles anthrax in sheep, the spleen is not enlarged and the blood is normal in color.

Treatment.—Medicinal treatment has no value in anthrax. The hypodermic injection of antianthrax serum is an effective treatment in the case of animals which show a rise of temperature but which have not yet developed visible symptoms, or in mild or chronic cases.

The exposed members of the flock which do not show abnormal temperatures (above 104° F.) should be immunized by the simultaneous method, which consists in the injection of a spore vaccine and antianthrax serum at the same time. Biological firms dealing in antianthrax serum and vaccine specify the proper doses of their products. Whenever possible, vaccination should be conducted by a veterinarian.

Affected flocks should be removed from anthrax-infected ground as soon as possible, even though immunity measures are being instituted, in order to lessen the exposure to gross infection. Care should be taken that public roads or adjacent premises are not exposed to contamination by infected flocks.

Prevention.—On anthrax-infected farms the wisest course is to vaccinate annually, as immunity can not be depended upon to last for a longer period than one year. Flocks outside of anthrax-infected localities should not be injected with living antianthrax products, because of the danger of establishing new anthrax centers.

Sheep are very susceptible to anthrax inoculation; hence care should be taken that an overdose of either the spore or Pasteur vaccines is not given. The dose should not be greater than one-sixth of the dose for cattle.

To guard against infection of the soil all carcasses and animal discharges should be destroyed by burning or by burying deep and covering with quicklime. Animals should not be skinned or cut open except for diagnostic purposes. Great care should be taken in handling animals affected with anthrax, as man is susceptible to the disease. Buzzards and dogs may easily carry infected material. Infected land should be quarantined or fenced in. Drainage and cultivation of the soil will eliminate the danger to a great extent. Small streams which drain infected areas or into which carcasses of animals which have died from anthrax have been thrown may infect pastures downstream.

BLACKLEG.

(Quarter ill, black quarter, emphysematous anthrax.)

Blackleg is an infectious disease which is confined to certain areas where the soil is infected with the blackleg organism.

Cause.—The disease is caused by the *Bacillus anthracis symptomatici.* Infection is introduced through minute punctures of the skin by thorns, spines, or burs.

Symptoms.—A swelling appears under the skin on any part of the body except below the knee or hock joint. It frequently appears either on the hind-quarter or shoulder and often on the face, jaws, neck, or breast. Several of these tumors may form simultaneously. They increase rapidly in size and in a few hours may cover a large surface. Pressure on the swelling may produce a crackling sound, due to the presence of gas in the tissue. The wool in some cases is shed over the affected part. Lameness or stiffness is usually evident. If the tumor is lanced, a frothy, dark-red fluid is discharged. The formation of the tumor is accompanied with general symptoms consisting of high fever, increased respiration, suspension of rumination, and great depression. The disease nearly always terminates fatally in a few hours after symptoms are apparent.

Post-mortem appearance.—The affected muscles are dark red or black, soft, and infiltrated with bloody liquid and gas bubbles. They have the odor of rancid butter. The internal organs, as a rule, do not show marked changes, and the blood, except in the diseased areas, appears normal and clots readily.

Diagnosis.—Blackleg swellings are distinguished from anthrax swellings by their soft, gaseous condition and deep muscular involvement. Anthrax swellings are hard and do not have the peculiar sweetish-sour odor of blackleg. In blackleg the spleen is unchanged and the blood clots readily. Malignant edema swellings are quite similar to blackleg swellings and also contain gas. They arise from larger wounds or surgical operations and may follow careless castration, docking, or shearing.

Treatment.—Animals may be protected against blackleg by the injection of blackleg vaccine specially prepared for sheep. Medicinal treatment is unsuccessful.

MALIGNANT EDEMA.

(Gas gangrene.)

Malignant edema is an acute febrile disease caused by a wound becoming infected. It is manifested by gangrenous swelling at the point of infection. It occurs after castration, shearing, docking, or in connection with injuries.

Cause.—The organism, *Bacillus edematis maligni*, which causes the disease, is found almost everywhere in the soil.

Symptoms.—Several hours after castration, shearing, or docking, and when infection with the organism occurs, a swelling develops around the wound and spreads beneath the skin. Gas forms and a clear or reddish fluid containing gas bubbles issues from the wound. The animal's temperature usually is from 106° to 108° F. Respiration is rapid and diarrhea is frequently present. When the animal moves, the hind legs are drawn forward with a peculiar, stiff, dragging motion, as if there were no joints.

Post-mortem appearence.—On removal of the skin the region between the hind legs and underneath the tail is found to be gangrenous and contains a dark-colored fluid and gas, or this condition may be found on other parts of the body, depending upon the seat of the infected wound. No characteristic changes are found in the internal organs.

Diagnosis.—Diagnosis rests on the appearance of a spreading, gangrenous, gaseous swelling at the seat of operation after castration or docking or around a wound made in shearing.

Treatment.—Medicinal treatment is useless. Disinfection of wounds or areas of operation prevent infection. Instruments used in operating should be sterilized before using. Sheep and lambs, after operation, should be placed for a time in lots or barns which have been cleaned and disinfected.

HEMORRHAGIC SEPTICEMIA.

(Catarrhal fever, pneumoenteritis.)

Hemorrhagic septicemia is an infectious, febrile disease. It occurs in both the acute and chronic forms. Lambs are affected mostly by the acute form, grown sheep by the chronic form. Death may ensue several hours after illness is noticed, or within two or three days. The chronic form may continue for several weeks.

Cause.—A germ known as *Bacillus ovisepticus* is the cause of the disease. (See fig. 1.) This organism may live in the air passages of normal sheep without producing harmful results. Under certain conditions, however, the nature of which is not clear, the virulence is increased to such an extent that severe outbreaks of hemorrhagic septicemia occur. The organism may also become active when animals are suffering from other diseases. When virulence is attained the disease may spread from animal to animal by means of infected feed or water.

Symptoms.—In the acute form, dullness, weakness, and a general constitutional disturbance are first noticed. The appetite is lost, thirst increased, and the temperature raised. Symptoms of pneumonia are manifested by difficult breathing and coughing. A serous or purulent discharge may pass from the nose and also from the eyes. There may be colicky pains. Diarrhea sets in, the excrement being dark or greenish yellow and fetid. Suckling lambs and lambs at weaning time are rapidly overcome. Severe outbreaks of hemorrhagic septicemia may be seen in mature sheep, but as a rule the latter are more resistant.

The chronic form is indicated when animals are less severely attacked or have survived an acute attack and suffer from a chronic affection of the lungs. A panting respiration, frequent cough, and a mucopurulent discharge from the nose and sometimes from the eyes are present. The body becomes thinner. There is stiffness and sometimes swelling of the joints, especially of the knee joints.

Post-mortem appearance.—Except in the very acute form the lungs show evidence of pneumonia. The heart frequently has hemorrhagic spots on its surface. The internal lining of the fourth stomach and intestines is congested and shows hemorrhagic spots. A watery or fibrinous discharge is found in the abdominal and lung cavities. The spleen, liver, kidneys, and lymphatic glands are congested or hemorrhagic in spots.

Diagnosis.—Hemorrhagic septicemia is distinguished from anthrax by the absence of a greatly enlarged, discolored, softened spleen, and by the fact that the blood usually appears normal and also clots in hemorrhagic septicemia.

Treatment.—There is no successful treatment known for sheep or lambs suffering from acute hemorrhagic septicemia. The sick animals should be isolated and the flock moved to new ground. Stables should be cleaned and disinfected frequently. Antihemorrhagic-septicemia serum and vaccine are used with considerable success in immunizing exposed sheep.

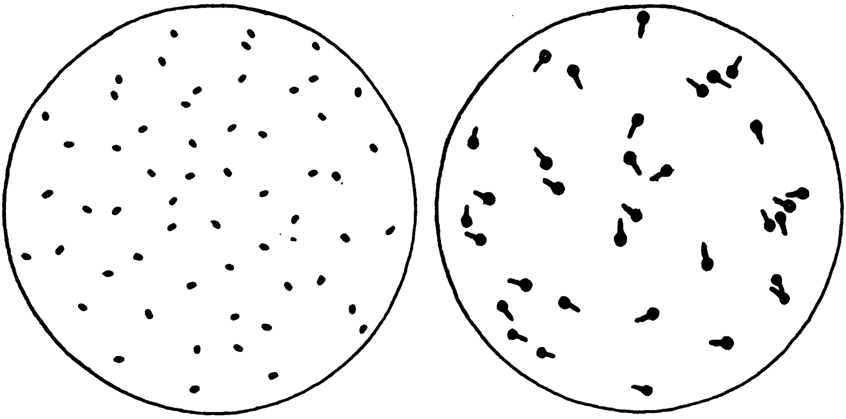

FIG. 1.—Types of microorganisms causing infectious diseases of sheep. Left, *Bacillus ovisepticus,* cause of hemorrhagic septicemia. Right, *Bacillus tetani,* cause of tetanus. The organisms are magnified 1,200 times.

TETANUS.

(Lockjaw.)

Tetanus is an acute, infectious disease manifested by persistent, spasmodic contractions of the muscles of the body.

Cause.—The disease is caused by the *Bacillus tetani*, an organism which is found in the soil. (See fig. 1.) The animal becomes infected through wounds contaminated with infected soil. The tetanus organism gives off a highly poisonous toxin, which acts on the nerve cells and causes muscular irritability and spasms.

Symptoms.—Symptoms are acute in sheep and recoveries are exceptional. Death usually occurs in two or three days, but the animal may live a week. Stiffness is first noticed. The nose is held high, the tail elevated, and the back arched. Later the muscles are contracted, the head drawn backward, and the jaws locked. There is marked excitability; noises and sudden movements cause spontaneous muscular contraction. The animal lies on its side with legs rigidly extended.

Lambs, 48 hours after birth, may show symptoms as a result of navel infection. Large outbreaks may occur after castration, docking, or earmarking. Death usually comes early in lambs. Ewes may become infected following labor.

Treatment.—Animals showing symptoms may respond favorably to treatment with large doses of antitetanus serum if injected early in the course of the disease. Because of the expense this would be practicable only in the case of valuable animals. When tetanus breaks out after castration or docking, the exposed animals may be protected by the serum treatment. Protective inoculation requires a much smaller quantity of serum than is required for treatment of animals showing symptoms. The entire flock should be removed from quarters in which the disease exists.

LIP-AND-LEG ULCERATION.

(Necrobacillosis, sore mouth, contagious foot rot, warty lip, venereal disease.)

The disease known as lip-and-leg ulceration is widely distributed in the United States. It is characterized by the formation of ulcers on any part of the exterior of the body, but principally (in the order named) on the lips, nose, chin, cheeks, gums, hard palate, legs and feet, and on the sheaths of bucks and wethers. The tail stumps of docked lambs, slit ears, shear cuts, and the vulvæ, udders, and teats of ewes may also be the seat of ulcers.

Cause.—The organism *Bacillus necrophorus* causes the disease. It gains entrance to the tissues through wounds or abrasions from various sources and sets up areas of inflammation and decay. The bacillus, which is widely distributed in nature, will not penetrate the uninjured skin.

Symptoms.—In the lip-and-leg form the lesions in some flocks are confined largely to the lips and muzzle, in other flocks to the legs, while in still others the seat of the lesions is about equally divided between the lips and legs. (See figs. 2 and 3.) The mouth form is common in lambs. In the venereal form the genital organs of both sexes are attacked. In bucks the external part of the sheath is most frequently affected, and less often the ulcerations are confined to the penis. In ewes the skin and mucous membrane of the vulva, the underside of the tail, and the skin below the vulva show lesions.

In the foot-rot form the lesions appear in the cleft, at the heel, or around the coronet. The degree of lameness depends on the severity of the foot lesions.

All forms of the disease may be found at times in the same flock. Sex or age does not appear to have any effect on the susceptibility of the animals.

The active stage manifests itself in the various locations by inflammation, swelling, ulceration, and gangrene, with or without scab formation. There may be considerable sloughing of the affected parts. A typical offensive odor, similar to that of Limburger cheese, is given off from the infected parts. The chronic stage is characterized by a stationary condition of the ulcers, without swelling or aeute inflammation.

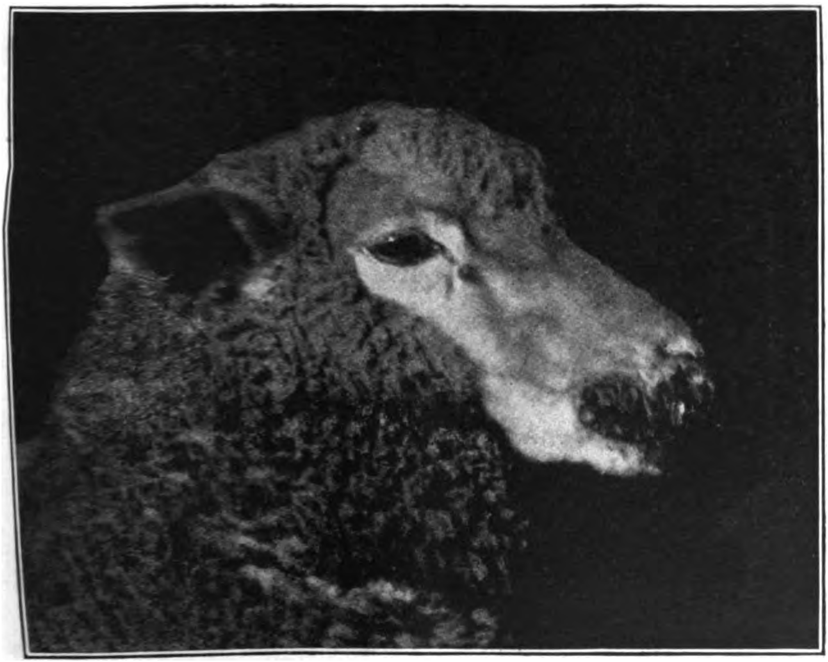

FIG. 2.—Lip-and-leg ulceration, showing lip lesions in ewe infected with germs obtained from warty lips of lamb.

Losses from lip-and-leg ulceration are at times severe, reaching as high as from 20 to 30 per cent of the flock.

Treatment.—Treatment of this disease by local antiseptics is very satisfactory if begun in time and applied energetically. In mild, unadvanced cases the best results are obtained by removing the scabs and shreds of tissue from the diseased areas with a piece of sharpened wood. Then apply three or four times weekly a 3 per cent solution of one of the cresol or coal-tar dips, or, better, a dressing containing 5 parts of one of these dips, 10 parts of sublimed sulphur, and 100 parts of mutton tallow, vaseline, or lard.

In actively progressive cases or in aggravated chronic forms it is desirable to remove the scabs, scrape all the soft, spongy tissues from the ulcers, and touch the affected area with a 10 per cent solution of zinc chlorid or with nitric acid in the strength of 1 part to 7 parts of water. The healthy skin surrounding the ulcers may be smeared with tallow, vaseline, or other oily substance to prevent injury from the

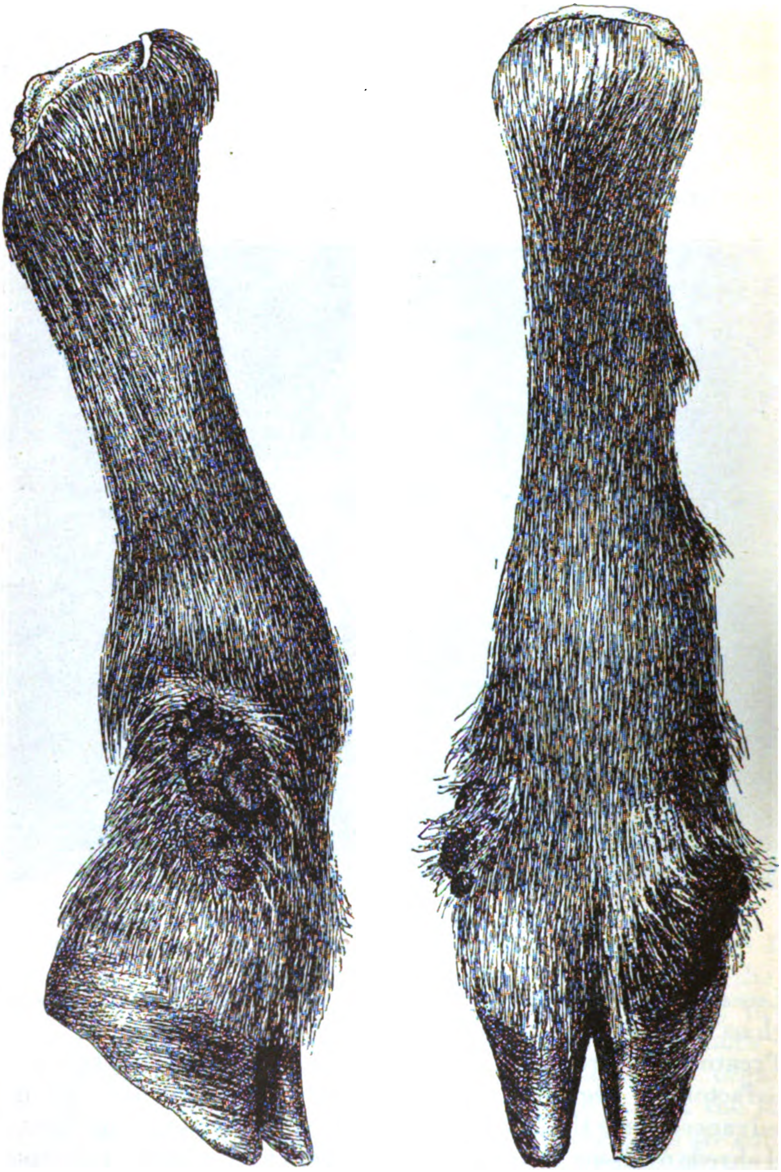

FIG. 3—Lip-and-leg ulceration, showing leg lesions.

caustic solutions. After using either of the caustic solutions the subsequent treatment should consist of three applications weekly of the above-named dressing, which is antiseptic but not caustic.

Boils or abscesses should be opened with a knife, cleaned out, and dressed with the antiseptics mentioned. Portions of diseased or loosened hoofs should be cut away. Affected animals should be separated from the healthy ones, and pens, corrals, and sheds thoroughly disinfected.

NONCONTAGIOUS FOOT ROT.

(Canker of foot, fouls, cutaneous abscesses, stoppage of biflex canal.)

Noncontagious foot rot is distinguishable, as described below, from the contagious form known as lip-and-leg ulceration.

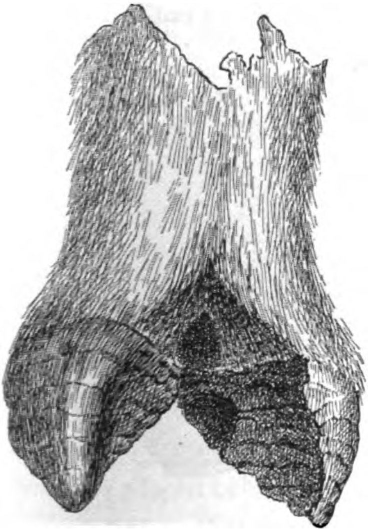

FIG. 4.—Early stage of foot rot. (After Brown.)

Cause.—Purulent inflammation of the cleft in the foot may occur in sheep pastured in low, swampy lands, or from accumulation of clay mixed with twigs, stubble, sharp pebbles, etc., in the cleft.

Wounds and cuts from stiff, pointed cut-over bushes, weeds, stubble, etc., may become filled with sand and fine gravel and may result in lameness and pus formation.

The opening of the biflex gland, situated between the toes of sheep, may become plugged by mud or sand. This not only stops the flow of the oily secretion for lubricating the tissues in the cleft of the foot but causes inflammation and the formation of pus in the biflex canal.

Sores or abscesses varying in size from that of a millet seed to that of a silver dollar may appear just above the coronet or in the region of the ankle as a result of sheep having to wade daily through muddy or filthy yards or pens. The abscesses are caused by pus-producing organisms different from the organism of lip-and-leg disease.

Symptoms.—In all forms of noncontagious foot disease lameness is a prominent symptom. An examination of the affected feet, the fact that few animals suffer from the ailment in most cases, and a consideration of the probable causes will help one to distinguish the disease from the contagious foot rot known as lip-and-leg ulceration.

Treatment.—Foreign material, such as caked clay, sand, pebbles, etc., should be removed, wounds or cracks washed, abscesses opened with a clean, sharp knife, and antiseptics, such as 5 per cent carbolic acid or 2 per cent compound solution of cresol, applied to the affected parts. Poultices may be applied to open abscesses and held in place for several days by a bandage. Portions of diseased or loosened hoofs should be cut away. Removal of the flock from muddy or filthy surroundings to dry, clean places checks the spread of the abscesses.

NECROBACILLOSIS OF THE NAVEL OF LAMBS.

Cause.—The organism *Bacillus necrophorus*, which causes lip-and-leg ulceration, may be responsible also for extensive outbreaks of an internal disease of lambs. The organism gains access to the liver by way of the navel cord during the first day or two after birth.

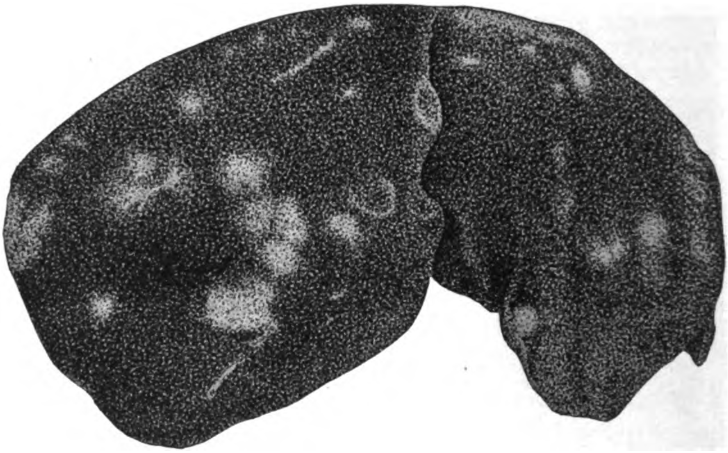

FIG. 5.—Liver of lamb, showing necrotic spots.

Symptoms.—The disease is rapid in its course. The affected animal shows general symptoms of disease and death follows in from 2 to 10 days after birth. In one case reported in Nevada more than 1,500 lambs died from this trouble out of 5,200 lambs born on the ranch that season.

Post-mortem appearance.—The most characteristic lesions are the presence of grayish, diseased spots up to 2 inches in diameter on the liver. These areas may spread to adjacent organs by contact. When cut into, the diseased spots give off a peculiar, offensive, gluelike odor.

Treatment.—Medicinal treatment is ineffective. The disease is prevented by good sanitary conditions at lambing time. If it has broken out the flock should be moved to new ground or quarters.

The navel cord should be disinfected soon after birth with 10 per cent carbolic acid or 5 per cent compound solution of cresol and preferably tied close to the navel.

WHITE SCOURS OF LAMBS.

(Infectious diarrhea.)

White scours is an acute, infectious disease manifested by profuse diarrhea. It attacks lambs shortly after birth or within two or three days, frequently affecting all the newborn in the flock. It is not common in range flocks.

Cause.—A variety of microorganisms has been found associated with the disease, but the most common of them is the *Bacillus coli communis.* Dirty lambing pens or ground contaminated with the virulent organisms soils the udders of the ewes and the organisms are taken up by the lambs in suckling. Cold and rain weaken the young lambs and predispose them to infection.

Symptoms.—Symptoms appear in from one to three days after birth. The lamb stops suckling, is depressed, and lies down much of the time. The feces may be yellowish or grayish white and may be tinged with blood. They are fetid and fluid. Death occurs in from one to several days after symptoms are shown.

White scours is distinguished from simple diarrhea by its tendency to affect a large number in the flock at the same time.

Treatment.—Affected lambs should be isolated and given 2 teaspoonfuls of castor oil and an internal antiseptic, such as salicylic acid in doses of one-third teaspoonful daily for several days. Anti-white-scours serum may be injected shortly after birth as a preventive. On farms where the disease has already occurred, ewes should be placed before lambing in clean, disinfected quarters.

JOINT ILL OF LAMBS.

(Navel ill, septic joint disease.)

Joint ill is an acute, infectious disease of newborn lambs which is characterized by swelling of the navel and joints of the limbs.

Cause.—Several common disease-producing organisms may cause joint ill. Infection occurs principally before the stump dries, by way of the vein of the torn navel cord, which has become soiled by dirt or other material harboring the pathogenic organisms.

Symptoms.—Signs of the disease usually occur within 48 hours after birth. The navel cord swells, contains a purulent secretion, and dries slowly. The animal is dull, lies down a good deal, and loses the desire to suck. There is stiffness and swelling of the hocks, stifle joints, or knees. A purulent secretion may escape from an opened joint. There may be a general septic condition.

Treatment.—Not much can be done in the case of badly affected animals other than to open and disinfect the navel stump and to nourish the animal artificially with milk. Recovery is rarely complete.

To prevent the disease place the pregnant ewes, shortly before lambing, in clean, disinfected quarters containing clean, fresh straw. Wash the navel cord of the newborn lamb with 10 per cent carbolic-acid solution or 5 per cent compound solution of cresol as soon after birth as possible and repeat daily for two or three days. Tying the navel cord close to the navel is also advisable.

CASEOUS LYMPHADENITIS.

(Cheesy bronchopneumonia, pseudotuberculosis.)

Caseous lymphadenitis is a chronic, infectious disease of the lymphatic system. The disease is common in the United States and many cases are observed by inspectors in slaughtering establishments.

Cause.—It is caused by an organism, the bacillus of Preisz.

Symptoms.—The presence of the disease is seldom noticed except through post-mortem examination. Because of its slow, chronic course it has no marked effect upon lambs and sheep marketed before they are 2 years old. In older animals the prescapular lymph glands (in front of the shoulder) and the precrural lymph gland (in the flank) may be enlarged to the size of an egg or larger and may be readily seen or felt. The animal may show unthriftiness or emaciation. Fatal cases are rare.

Post-mortem appearance.—One or more of the lymp glands of the body wall and internal organs are greatly enlarged and filled with a greenish-yellow cheesy mass. The lungs may be studded with small tumors the size of a pea, and the liver and spleen may contain one or more tumors. These show the same characteristic greenish-yellow material. Chronic pleurisy and lung adhesions are often present.

Diagnosis.—The disease is distinguished from tuberculosis, which is rare in sheep, by the greenish-yellow, cheesy appearance of the tumors.

Treatment.—No remedy is effective. The meat of animals which do not show extensive lesions or emaciation is fit for food. Affected parts should be destroyed.

TUBERCULOSIS.

(Consumption.)

Tuberculosis is a chronic infectious disease characterized by the formation of caseous nodules or tubercles in the lymphatic glands and internal organs. It is very rare among sheep in America.

Cause.—The organism *Bacillus tuberculosis* causes the disease. It is contracted by exposure to infected animals, whose discharges contaminate the feed, drinking water, or air. Infection from contact with tuberculous cows has been reported.

Symptoms.—There is a gradual emaciation associated with lung trouble and coughing. The lymph glands of the throat may swell and cause bloating.

Post-mortem appearance.—Some of the lymph glands of the head, throat, chest and abdominal cavities, or body wall are enlarged and contain a yellowish, cheesy, or gritty material. The lungs, liver, spleen, or kidneys may be the seat of tumors containing such material.

Diagnosis.—The disease may be confused with caseous lymphadenitis, a common disease of sheep. The tumors of the latter disease are usually composed of greenish-yellow, cheesy material. Tuberculosis may be diagnosed by the application of the tuberculin test.

Treatment.—No treatment is effective. Tuberculous animals should be destroyed.

RABIES.

(Hydrophobia.)

Rabies is an acute, infectious disease affecting the brain, ending in paralysis and death.

Cause.—It is caused by a living virus which is transmitted to animals and man by the saliva of rabid animals through biting. Dogs are most frequently responsible for the spread of rabies, but any affected animal that bites another may transmit the disease.

Symptoms.—Symptoms begin between two and four weeks or somewhat longer after the animal is bitten. Death takes place in from two to eight days later. There is loss of appetite and a stopping of rumination, great unrest, stamping of feet, and butting or charging others of the flock. The affected sheep will attack a dog or other intruder. The head may be carried high and a little to one side. Bleating is higher in tone and more plaintive. Increased sexual excitement is marked, especially in the rams, the animals continually riding one another indiscriminately. Sheep will nibble at wood and swallow indigestible material of any kind. Occasionally a form of dumb rabies is found, in which violent symptoms are not pronounced. Lambs have convulsive fits and die in a day or two. Paralysis of the limbs precedes death.

Post-mortem appearance.—No characteristic changes are observed in the internal organs, except through microscopic examination of the brain. The finding of small, round, foreign bodies, known as Negri bodies, in the brain cells, establishes a positive diagnosis of rabies.

Treatment.—Affected sheep can not be cured. Those known to have been bitten by rabid animals may be protected against the disease by the Pasteur vaccine treatment if promptly given. This is expensive, but may be warranted in the case of valuable sheep.

FOOT-AND-MOUTH DISEASE.

(Aphthous fever.)

Foot-and-mouth disease is a highly infectious, acute, febrile disease of cloven-footed animals. Horses, dogs, cats, poultry, and even man may become infected. It is characterized by the formation of vesicles or blisters on the membrane of the mouth and on the skin between the toes and above the hoofs. The disease does not exist in the United States. Since it has broken out on several occasions, however, through infection from abroad, it is a disease with which every livestock owner should be familiar.

Cause.—The cause of the disease is too small to be seen with a microscope and is known as a filterable virus. Transmission occurs by direct contact with infected animals or by any agency, such as man, other animals, feed, animal products, etc., contaminated with discharges from affected animals.

Symptoms.—In sheep the lesions are more pronounced in the feet, the blisters being less well marked in the mouth than is the case in cattle. All four feet generally are the seat of small blisters, which form on the skin between the toes, on the heel, or around the top of the hoof. The animal is restless and kicks with the hind feet. Pain becomes intense, severe lameness is shown, and the animal rests on the knees or breastbone in feeding or lies down most of the time. The blisters rupture, discharging a clear or yellowish fluid, which later may become cloudy or purulent. Frequently the hoof separates from the wall.

In the mouth small blisters form on the incisor pad, lips, tongue, cheeks, or hard palate. These rupture, discharging a clear fluid and leave small, reddened surfaces which heal rapidly. A considerable part of the membrane of the mouth may be cast off. The animal often makes a smacking sound or grinds the teeth.

Blisters may appear on the udder or teats. There is a general constitutional disturbance, diminished appetite, and loss of condition. The temperature rises at first and then drops to normal.

The disease runs its course in from two to three weeks, but is prolonged by severe foot lesions or by complications. The mortality is higher among lambs than among grown sheep.

Diagnosis.—Foot-and-mouth disease is readily recognized by the rapid spread of the disease in a flock, or to cattle and hogs, by the characteristic blisters on the feet or in the mouth and by the severe lameness in more than one foot. In foot rot of sheep, lameness is present in the affected foot; but in that case the lesions are in the form of ulcers, which usually develop at the heel and may extend deeply into the tissues, causing erosions which discharge a purulent matter. A pungent, disagreeable odor also is quite characteristic of foot rot.

Treatment.—Medical treatment is not practiced in this country, as the danger that the disease will spread from an infected flock is too great. On each occasion when an outbreak has occurred slaughter of the affected herds as early as possible has prevented the disease from gaining a permanent foothold in the country. During outbreaks of foot-and-mouth disease suspicious cases should be immediately reported by telegraph to the State livestock authorities or to the United States Bureau of Animal Industry.

SHEEP POX.

(Variola ovina.)

Sheep pox is an acute, infectious, eruptive disease of the skin, which spreads rapidly through a flock. It is prevalent in Europe, but is not known to exist in America.

Cause.—Sheep pox is caused by a living, filterable virus, and is contracted principally by inhaling dust and air containing pox-scab material.

Symptoms.—The disease begins with high fever and general constitutional disturbance. Round, red spots appear on the parts of the skin which are free from or only lightly covered with wool. Papules soon develop on these spots and are succeeded by vesicles containing a yellowish or pale-red fluid. The vesicles later become pustules and then dry up to form a scab which is cast off. The animal gives off a peculiar, sweetish, repulsive odor. The disease lasts about three or four weeks, and the mortality except in severe outbreaks runs from 5 to 10 per cent.

Treatment.—European authorities advise slaughter of the first animals affected. Preventive vaccination is successful, but is carried on under Government permit, because of the danger of spreading the disease.

ACTINOMYCOSIS.

(Lumpy jaw, wooden tongue.)

Actinomycosis is a disease rare in sheep, caused by the ray fungus *Actinomyces bovis*, which forms cheesy tumors in the tongue. Occasionally the lips, jaws, or lungs may be affected.

Treatment.—Give 2 grains of potassium iodid in the drinking water daily for a period of two weeks.

GENERAL DISEASES.

JAUNDICE.

(Icterus, yellows.)

Jaundice is a common disease of sheep, but is not often noticed except at slaughter. It is characterized by the yellowish appearance of the tissues of the body.

Cause.—Jaundice results from various affections of the liver, flukes being a common cause. When the bile does not flow freely into the intestine the coloring matter is absorbed into the blood, and a yellowish coloration of the body results.

Symptoms.—The membranes of the mouth, nostrils, and eye are yellowish. The urine is stained varying shades of yellow. On postmortem the carcass shows a yellow discoloration which often disappears after a day or two.

Treatment.—A purgative, such as Epsom salt or Glauber's salt, 4 ounces, may be given, likewise opportunity for exercise.

ICTEROHEMATURIA.

(Red water, malarial fever, jaundice.)

Icterohematuria is a highly fatal, febrile disease which is apparently restricted to limited areas. It has been reported from certain valleys in Montana and from Colorado.

Cause.—In Europe the disease has been attributed to a blood parasite of miscroscopic size. In this country its cause has not been definitely established.

Symptoms.—Severe cases are characterized by weakness; reddish or bloody urine; yellowish coloration of the membranes of the eye and nostrils; swelling of the head, ears, or neck; stupor; unconsciousness; and sometimes convulsions followed by death in from two to five days after symptoms are noticed. In mild cases no marked symptoms may be observed, but yellowish discoloration of the body tissues is seen on slaughter.

Post-mortem appearance.—The skin and fat are yellowish in color, and the muscles slightly yellowish. The blood is pale, the liver is yellowish and easily crumbled, and the gall bladder is filled with yellowish-green or greenish-black bile. Kidneys are enlarged, soft, and contain a bloody or dark-colored urine. The bladder contains bloody or chocolate-colored urine. Yellowish or yellowish-green gelatinous liquid is found beneath the skin, between the muscles, or in the body cavities.

Treatment.—Quinine, one-third teaspoonful twice daily, is recommended, also Epsom salt or Glauber's salt, from 2 to 4 ounces. The disease is prevented by keeping sheep away from pastures where the condition exists.

PERITONITIS.

Peritonitis is an inflammation of the membrane lining the belly cavity and covering the abdominal organs.

Cause.—It is seen generally after castration of lambs or following inflammation of the womb in ewes. It results from infection.

Symptoms.—The principal symptoms are evidences of abdominal pain. There is plaintive bleating, grinding of the teeth, and the animal frequently draws the head around toward the flank. The temperature rises. The hind legs may be dragged stiffly and the belly may be tucked up. Fluid may be felt in the belly.

Treatment.—The castration wound should be washed with antiseptics. Stimulating liniments or mustard water may be applied to the abdomen.

ASCITES.

(Abdominal dropsy, water belly.)

The condition known as ascites represents an accumulation of fluid in the belly.

Cause.—Ascites may be present in several general diseases, and in peritonitis, internal parasitic infestation, or in debilitated animals, especially during pregnancy.

Symptoms.—Gradual enlargement or bulging of the belly is a common symptom. Manipulation of the belly will cause the fluid to fluctuate or move about. There is a dull sound on thumping the abdomen. Affected ewes may give birth to water-bellied lambs.

Treatment.—The ailment which causes the condition should be treated. Give one-half teaspoonful of potassium iodid daily in a little water as a drench. The belly may be tapped and the fluid drawn off.

ANEMIA.

(Hydremia, chlorosis.)

Anemia is a condition in which the blood is deficient in either quality or quantity.

Cause.—It is most frequently due to insufficient feed or to feed deficient in proteins and mineral substances, such as iron. It occurs often in animals grazing on marshy pastures. Ewes suckling lambs become anemic when the quantity or quality of feed is inadequate for their needs. Anemia is also associated with chronic wasting diseases and with heavy infestation with parasites.

Symptoms.—The visible membranes of the eye, nose, and mouth are pale. There is dullness, weakness, and emaciation. A dropsical swelling forms under the lower jaw and may extend down the neck to the chest. The belly becomes dropsical. The wool is lusterless, harsh, or brittle, and falls off in patches. Diarrhea is present in the late stages. The animal may die from loss of strength after several weeks, or the disease may continue for months.

Treatment.—Change of feed or pasture is essential. A sufficient quantity of nutritious feed should be given; also administer iron sulphate (copperas) in from 8- to 15-grain doses daily. Arsenic in the form of Fowler's solution in from one-quarter to 1 teaspoonful daily and vegetable tonics, such as gentian or ginger, in from 1 to 2 teaspoonful doses are of value in aiding rapid recovery.

RICKETS.

(Rachitis, leg weakness.)

Rickets is a disease of lambs in which the bones are soft and flexible from retarded hardening due to lack of proper mineral salt.

Cause.—Failure of the bones to receive enough mineral salts, especially lime, may be due to faulty processes in the body, but is usually due to lack of lime salts in the feed and to lack of exercise. Suckling lambs may become affected if the mothers do not get feed enough, or if the feed is low in lime content. Some soils are deficient in lime, and feed grown on them is also deficient. Lambs closely confined, even if properly fed, may develop rickets.

Symptoms.—The symptoms are most apparent in the long bones of the legs. Nodular enlargements may be observed on the ends or sides of the bones, which are soft and porous. They are bent or bowed outward, inward, or backward. The spine may be curved also. Stiffness or lameness is present. The animal does not like to move about, lies down a good deal, or crawls about and kneels when eating. The second set of teeth is slow in coming. The licking or nibbling of walls is observed, and there is a desire for filth and for foul water.

Treatment.—Lambs should not be penned closely, but should be allowed plenty of room for exercise. They should also have nutritious feed, grown on good soil. Lambs should be given new pasture or plenty of green feed, timothy hay, clover, alfalfa, pea hay, oats, linseed cake, or other feeds rich in lime and phosphates. Dams of nurslings should be well fed on such feeds. Chalk (calcium carbonate) may be given to ewes with suckling lambs, or to lambs, in doses of from one-half to 2 teaspoonfuls daily, or sodium phosphate may be alternated with the chalk.

GOITER.

(Big neck, woolless lambs.)

Goiter is characterized by a swelling of the thyroid gland, which is situated in the throat just below the lower jaw. It is quite common in sheep in various regions. Lambs from affected flocks show absence of wool and enlargement of the throat. Many are born dead, and some die shortly after birth. Those that live are often unthrifty.

Cause.—The disease is caused by lack of iodin in the thyroid gland. This appears to be due to a scarcity of iodin in the vegetation and water in certain districts. Where the pregnant ewe can not get iodin enough the normal growth of the fetus is arrested.

Treatment.—In flocks where the disease exists pregnant ewes should be given potassium iodid daily for three months before lambing. One-half ounce of potassium iodid mixed with one-half ounce of milk sugar and dissolved in the drinking water daily is sufficient for 100 ewes.

RHEUMATISM.

Cause.—Rheumatism does not occur so often as a separate affection as formerly believed. Symptoms of soreness, lameness, or stiffness associated with various internal diseases are popularly termed rheumatism. Rheumatism, independent of other ailments, is generally due to cold drafts and dampness. It affects the muscles and to a less extent the joints. Young animals are usually affected.

Treatment.—Protection against the causes, with application of stimulating liniments to the affected parts, will help restore the animal to health.

WOOL EATING.

Cause.—Wool eating is observed principally in winter, when sheep are confined to close quarters. It is often only a bad habit, which, when started by one or more animals, is imitated by others. In other cases lack of essential mineral elements in the feed may cause the habit.

Symptoms.—Lambs begin by gnawing the wool of their mothers, usually on the thighs and abdomen. Older sheep may select one animal and eat all its wool before turning to another. Wool eating may become general in the flock. A few lambs may become anemic, show digestive disturbance, or even die as the result of the formation of wool balls in a compartment of the stomach and the subsequent plugging of the intestine.

Treatment.—Wool eaters and their victims should be removed from the flock. Animals should be turned out for exercise, and nutritious feed should be provided.

DISEASES OF THE HEAD AND AIR PASSAGES.

BIGHEAD.

Bighead is characterized by a sudden swelling of the head and ears. The affection is not very widely distributed. It is found in Utah and the surrounding States, the greatest losses occurring in southern and central Utah, southern Idaho, eastern Nevada, and western and southern Wyoming. It is also seen occasionally in sheep brought as feeders from those regions into the Middle Western States. In such cases the disease occurs shortly after the arrival of the animals early in the autumn if heat is excessive.

Cause.—The definite cause of bighead is not known, though climatic conditions have much to do with its appearance. Sheep are usually affected during the spring and early summer while being driven from the winter to the summer ranges, more commonly before shearing. Bighead appears to be most prevalent after a cold or stormy night, when the day following turns hot and the animals are driven fast in the hot sun, and when they are compelled to inhale a considerable quantity of alkali dust. It affects males and females alike, though it is seldom seen in young lambs. This condition affects sheep in much the same way as man is affected by poison ivy. The disease is not transmissible from one sheep to another or to other animals. All experiments with transfusion of blood or injection of serum from the affected sheep to healthy ones were without results.

A disease of sheep in Europe, known as fagopyrism or buckwheat poisoning, is similar to bighead. In one experiment in America bighead was produced by feeding buckwheat and exposing the animals to the sun. In another experiment the results were negative. On the desert and on different parts of the trail sheep eat a number of plants that belong to the buckwheat family, and it is possible that the trouble may come from that source.

Symptoms.—The first noticeable symptom is that the animal begins to throw its head up and sidewise in a jerking manner. It is greatly irritated and shakes the head and tries to rub it. The animal walks aimlessly through the flock, often stamping its feet on the ground, and seldom standing still very long. The eyesight is affected, as the animal follows a direct line, sometimes running into other sheep and objects in its path. In that condition some of the sheep wander away from the flock and are lost, either dying as a result of exhaustion and starvation or becoming a prey to wild animals.

If the animal is watched after the jerking of the head begins, one can see the ears turn red and enlarge. At about the same time the cheeks show congested appearance. (See fig. 6.) Ears and cheeks continue to enlarge to enormous proportions, the ears drooping as a result of their weight. After the swellings are about complete, small drops of serum of a light-yellow color begin to exude from them. The entire face becomes so swollen as to close the eyes, and in some cases the internal pressure of the serum forces the eyeballs out of their sockets. Fever is always present and shows itself early, the temperature ranging from 104° to 107° F. In the severe forms this occurs in from 30 minutes to 1 hour. The vision being obstructed, the animal can not see its feed and the lips, cheeks, and tongue are so badly congested that eating is impossible. In many cases the tongue fills the mouth entirely. In some cases there is a disturbance of the breathing due to pressure on the trachea and inflammation of the air passages. To some extent this may be due to excitement, and when in that condition the sheep, if allowed to, will continue to chase around until completely exhausted and will then lie down, usually never to rise. Others that are only slightly affected may recover. The skin often cracks or peels off the swelled areas and many animals lose the wool over the entire body. Sheep

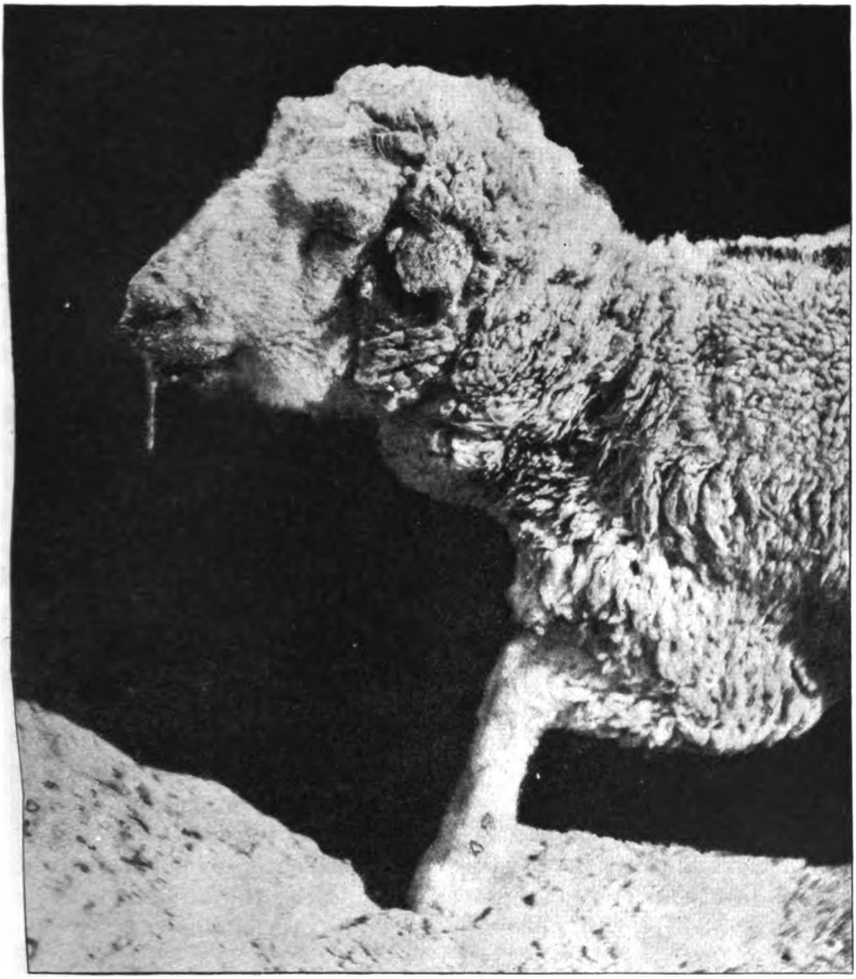

FIG. 6.—Bighead of sheep, showing swelling of eyelid, face, and ear (ear had been cropped). Scabs on ear, eyelid, and nose due to drying of exuded serum. Catarrhal, stringy discharge hangs from nose. (After Buckley.)

once affected are never so good as formerly, as they become unthrifty. Many of the ewes that carry lambs lose them.

Post-mortem appearance.—Sheep killed during the early stages of the disease show petechiæ (purplish spots) in the nostrils and all tissues of the head, trachea, and lungs. There is an accumulation of serous or jellylike fluid around the eyes, in the cheeks, between the ears, below the jaws, and under the mucous membrane of the mouth and tongue.

When sheep die as a result of this condition, the jellylike material is found in different parts of the body under the mucous and serous membranes and in some of the muscles. There are often small hemorrhagic spots along the intestinal tract and around the kidneys. There is a congestion and thickening of the walls of the lymphatics, with a swelling of the lymph glands. The blood circulation of the head in many instances is nearly shut off by the pressure of the swollen condition. The brain and spinal cord of the dead animal contain an excessive amount of serum. The muscle tissue appears normal in most parts of the body except the head.

Treatment.—Different medicinal substances were experimented with on affected sheep with the view of finding some specific that might overcome the trouble. The substances that do the animals most good are emollients, such as vaseline or olive oil, applied to the head. Whenever affected sheep have absolute rest and some protection from the direct rays of the sun and their heads are smeared with emollients they recover in a short time, while those that are not treated in this manner but are driven indefinitely without these precautions, become severely affected, many of them dying as a result.

The malady is prevented by handling sheep properly, not driving them too far or too fast on the trail during the heat, especially before shearing in the spring.

Sheepmen should not become excited when bighead develops in their flocks and cause the herders to rush the sheep over the ground, as they do where poisonous plants exist. Keep the animals cool so far as possible, and many great losses can be prevented.

SORE EYES.

(Conjunctivitis, ophthalmia, the blinds.)

Cause.—Disorders of the eye may arise from a number of causes. Inflammation may follow injuries, or inclusions of dust, seeds, pollen, etc., or may accompany other diseases, such as catarrh. At times inflammation of the eye becomes prevalent in a particular district or region.

Symptoms.—The eye is kept closed, especially when exposed to light. Tears flow freely. At first the discharge is watery, but later it may become purulent. The eye membranes are swollen and red. The eyeball may become clouded or milk white, and in bad cases it may ulcerate and rupture. Cataract and blindness frequently follow successive attacks of ophthalmia.

Treatment.—Any foreign matter in the eye should be removed. The eye should be washed with 3 per cent boric-acid solution, or, better still, after washing the eyes with lukewarm water place several drops of 15 per cent solution of argyrol on the eyeball. Treatment should be given twice a day, the animal being kept in a dark place if possible.

NASAL CATARRH.

(Snuffles.)

Cause.—Exposure to dampness, rain, or cold weather after shearing predisposes sheep to catarrh. Lambs with little wool are also susceptible. Continued exposure to bad weather, nasal affections, and parasites in the head may produce a chronic catarrh.

Symptoms.—In acute catarrh the discharge begins as a clear fluid, which later becomes thick, stringy, and yellowish. It may plug the nostrils by drying around the openings. The eyes also may become congested and show a discharge. In chronic cases a yellowish, fetid discharge continues from the nose and is especially marked after exposure to bad weather.

Treatment.—House or shelter the sheep in bad weather. The nostrils may be washed out and sprayed with cresol or coal-tar disinfectant in 2 per cent solution. Weak animals may be given a stimulant, such as sweet spirits of niter. Powdered carbonate of iron, 2 teaspoonfuls, and powdered gentian, 2 teaspoonfuls, may be given night and morning in the feed.

BRONCHITIS.

Cause.—Exposure to wet, windy weather or shearing or dipping in cold weather may cause an inflammation of the air tubes. Bronchitis may also follow nasal catarrh or may be due to worms in the air passages.

Symptoms.—There is a cough, which is dry and painful at first, followed by a moist cough. There is also a discharge from the nose and mouth.

Treatment.—Provide warm, dry quarters, and smear pine tar over the nostrils.

PNEUMONIA.

(Lung fever, congestion of the lungs, pleurisy.)

Pneumonia is an inflammation of the lungs, and may be brought on by a variety of causes. Young lambs are frequently affected by a severe form of septic pneumonia. Pleurisy often accompanies or follows pneumonia.

Cause.—The most important causes in sheep are microorganisms and parasites. Pneumonia is often associated with specific diseases, such as hemorrhagic septicemia, anthrax, or white scours of lambs. Several varieties of microorganisms produce pneumonia, especially in lambs when the animals become predisposed to infection through outside influences. Animals sheared during the winter months or dipped during cold weather may be attacked. Cold, wet, foggy seasons predispose to pneumonia. Lambs may be affected by sucking unclean udders or may contract an infectious form of pneumonia from other lambs. Wound infection following castration may produce pneumonia.

Symptoms.—There is fever, increased blowing respiration, flank breathing, cough, nasal discharge, and loss of appetite. The animal stands persistently or rests on the breastbone. In the septic form in lambs the course is rapid, deaths occurring in from two to six days. The more chronic forms last from three to six weeks. In the milder cases the condition generally improves and recovery is apparent after several weeks.

Post-mortem appearance.—On autopsy the lungs are found engorged with blood and one or both lungs may be solidified. The pleura may be inflamed and show adhesions with the lungs. The chest cavity may contain fluid.

Treatment.—The causes which predispose to pneumonia should be eliminated so far as possible by proper management and housing. Infected animals should be isolated and sanitary measures instituted. Flour and bran gruels should be given. Salicylate of soda should be given in the drinking water in the proportion of 2 teaspoonfuls to each gallon.

DISEASES OF THE DIGESTIVE SYSTEM.

DEFECTIVE TEETH.

Animals which show poor condition, indigestion, or dropping the cud may be found upon examination to have supernumerary, defective, or broken teeth, diseased gums, or, in the case of old ewes, teeth may have fallen out. Defective or supernumerary teeth should be removed, or the affected animals prepared for slaughter.

DROPPING THE CUD.

Cause.—When an animal drops the cud, disease of the teeth or sore mouth may be looked for. In other cases it is due to acidity of the stomach or inferior feed.

Symptoms.—The contents of the stomach are returned to the mouth for mastication, but owing to acidity, bad taste, or to pain in chewing, the feed is dropped from the mouth. Quantities of half-chewed feed may be found on the ground.

Treatment.—The mouth or teeth should be attended to if found diseased. Baking soda in from 1 to 2 teaspoonful doses will counteract excessive acidity of the stomach. A purgative, such as Epsom salt in 4-ounce doses, may be given. A good quality of feed should be provided.

STOMATITIS.

(Necrotic stomatitis, sore mouth of lambs, thrush.)

Stomatitis is an inflammation of the mouth. It may occur in several forms, as catarrhal, aphthous, necrotic, and mycotic.

Cause.—Catarrhal stomatitis, or simple redness of the mouth, is due to irritants in the feed or to irritating mineral or poisonous substances. Aphthous and necrotic stomatitis are caused by microorganisms. Mycotic stomatitis is caused by fungi or molds.

Symptoms.—In catarrhal stomatitis a diffuse redness of the membranes covering the tongue, cheeks, and hard palate is observed. In the aphthous form patches of yellowish-gray false membranes, made up of cast-off fibrin and exudates, are found on the tongue, gums, and at other points in the mouth and throat. In the necrotic form small ulcers or decayed spots are present. The mycotic form also presents ulcerated areas.

In all forms suckling or the taking of feed is painful. Saliva dribbles from the mouth. A disagreeable odor is given off. Frequently the animal is stiff in the limbs, and the back may be arched. There is an unthrifty appearance and loss of flesh. In very young lambs the disease takes a rapid and fatal course. Older animals generally recover.

Treatment.—Separate the sick from the healthy. Lambs unable to suck should receive milk artificially. Older animals should have bran mashes, ground feed, or gruels. The mouth should be swabbed out daily with such antiseptics as compound solution of cresol, carbolic acid, or permanganate of potash in 2 per cent solution. It is also beneficial to dissolve 2 tablespoonfuls of borax in each pail of drinking water.

CHOKING.

Cause.—Choking occurs as the result of the lodging of a piece of root or dry, coarse feed in the gullet.

Symptoms.—Difficult breathing, head stretched out, attempts to swallow or to vomit, stoppage of rumination, and bloating suggest choking. Feeling along the gullet will reveal the obstruction.

Treatment.—If the obstruction is near the mouth it may be fished out with the fingers or an instrument, or forced up by outside pressure. If further down, a little linseed oil may be given and the material pushed toward the paunch by means of a rubber tube or stout looped wire. In obstinate cases immediate slaughter may be advisable.

INDIGESTION.

(Impaction of rumen, atony of stomach, grass staggers.)

Cause.—Indigestion results from the presence of other diseases; from feeding coarse, fibrous, indigestible feed with little green feed; from spoiled feed; or from overloading the stomach. The fourth stomach of lambs may become impacted with curdled milk.

Symptoms.—There is dullness, loss of appetite and rumination, bad-smelling eructations, constipation with passing at long intervals of bad-smelling, dry, undigested dung in small quantities. The left flank may be distended and feel doughy to the touch.

Treatment.—Give purgatives, such as Epsom salt or Glauber's salt in from 2 to 3 ounce doses, or castor or linseed oil from 3 to 6 ounces. One-half ounce of turpentine may be mixed with the oil. Work up the paunch with the hands over the left flank. When the animal begins to eat give succulent green feed for a few days.

BLOATING.

(Hoven, tympanitis.)

Rapid formation of a large quantity of gas in the paunch causes a bloating or distension of the abdomen.

Causes.—Heavy feeding on various green feeds, such as alfalfa, clover, green oats, or pea vines, especially when wet or frosted, or on grains, frozen fruits or cabbages, turnips, etc., may bring on bloating. These feeds readily ferment when the paunch becomes inactive or paralyzed from overdistension and a large quantity of gas accumulates.

Symptoms.—Evidence of bloat is readily apparent. It appears first in the left flank as a tense swelling, which sounds drumlike on tapping with the hand. Breathing is difficult from pressure on the lungs, the animal is distressed, staggers, and drops to the ground. Death results from suffocation.

Treatment.—In acute cases the flank should be punctured in its most prominent part with a clean trocar and cannula and the trocar withdrawn to allow the gas to escape through the cannula. A stomach tube or small rubber tube passed down the gullet serves the same purpose. Large doses of antiferments and stimulants, such as aromatic spirits of ammonia, one-half ounce in 5 ounces of water, and turpentine, one-half ounce in 6 ounces of linseed or castor oil, should be given. Driving the animals through cold water or pouring cold water over the body is beneficial. Keeping the mouth open by gagging with a smooth stick tied behind the ears and massaging the paunch with the fist against the left flank will aid in causing a belching of gas.

GASTROENTERITIS.

(Inflammation of stomach and intestines.)

Cause.—Severe inflammation of the stomach, generally the fourth compartment or abomasum, and of the intestine is most often found associated with one of the infectious diseases or with extensive parasitic infestation. Other inflammations may be due to moldy or iritating feeds, poisons, and causes which are included among the causes of colic, indigestion, impaction, and bloat.

Symptoms.—There is loss of appetite, constipation followed by diarrhea, slimy or bloodstained feces, straining, colicky pains, and tenderness of the abdomen. The animal becomes poor, weak, and dull.

Post-mortem appearance.—The membrane lining the fourth stomach and intestine will be found inflamed, or covered by a catarrhal, slimy deposit. The membrane may be cast off in places. The cause of this inflammation is often apparent at autopsy.

Treatment.—Stimulants and purgatives are required. These may include aromatic spirits of ammonia from one-quarter to one-half ounce in 5 ounces of water or linseed oil, and castor oil or Epsom salt, 4 ounces. Nourish with warm, soothing drinks containing eggs or milk. Provide warm quarters and feed carefully during recovery.

COLIC.

(Bellyache, stretches.)

Cause.—Colic is an acute abdominal pain which may be due to a variety of causes, among which may be mentioned gastritis or inflammation of the stomach, enteritis or inflammation of the intestine, bloating, obstruction in intestine or stomach, twisting of intestine, indigestion, constipation, sand in stomach or intestine, gallstones in the liver and its ducts, kidney stones in the kidneys or urinary tubes, worms, and peritonitis.

Symptoms.—Pain is shown by uneasiness, moaning, grinding of the teeth, stretching, getting up and lying down frequently, striking the belly with the hind feet, and looking toward the flank.

Treatment.—Treatment naturally depends upon a proper diagnosis of the specific cause of the colic. Those forms which are most common and most amenable to treatment are benefited by giving stimulants and antispasmodics, such as sweet spirits of niter or turpentine, from one-quarter to one-half ounce, and purgatives, such as Epsom salt or castor oil, 4 ounces. Aftertreatment should consist in proper regulation of feed and careful nursing.

DIARRHEA.

(Dysentery.)

Cause.—Common diarrhea, as distinguished from white scours of lambs and from diarrhea associated with specific diseases, is due to disturbances in the digestive system from irritants in the feed, change to an abundance of succulent feed, spoiled feed, exposure after shearing, or to the presence of parasitic worms in the intestine.

Treatment.—The feed should be examined and regulated. Adverse conditions should be corrected. It is best to give a purgative, such as Epsom salt, 4 ounces, or castor or linseed oil, 4 ounces, to remove the irritating matter. If diarrhea persists, subnitrate of bismuth may be given in from one-half to 1 teaspoonful doses.

CONSTIPATION.

Cause.—Constipation may be a symptom of certain stages of general diseases. Simple constipation is due to digestive disturbances resulting from indigestible dry feed with insufficient water, wool balls, especially in lambs, or lack of exercise in stalled rams.

Symptoms.—The animal is dull, appetite is decreased, the mouth is dry, and sometimes colicky pains are evident. Attempts are made to defecate and the feces passed are hard and coated with mucus.

Treatment.—Grown sheep should be given 4 ounces of Epsom salt or Glauber's salt in a quart of water. Lambs should be given a smaller quantity, according to size, or 2 ounces of castor or linseed oil. Succulent green feed should be fed for several days.

RETENTION OF THE MECONIUM.

Retention of the meconium is observed in newborn lambs which fail to pass the dung soon after birth.

Symptoms.—There are evidences of colicky pains as a result of intestinal irritation.

Treatment.—Give an injection of linseed oil into the rectum; also a teaspoonful of castor oil by the mouth.

DISEASES OF THE NERVOUS SYSTEM.

MENINGITIS.

Meningitis is manifested by inflammation of the brain and spinal cord and their membranes. It is more often seen in lambs than in old sheep. Louping ill, a disease of sheep in the British Isles, is a form of meningitis.

Cause.—The exact cause is often obscure. The presence of microorganisms or their toxins, however, is nearly always responsible. The blood stream may carry infection to the parts from wounds resulting from injuries, or from local areas of pus infection following the castration or docking of lambs. Other infectious diseases may extend to the brain or spinal cord. Parasitic cysts may set up meningitis.

Symptoms.—The symptoms shown are due to changes in the cells of the brain or spinal cord. These are mainly staggering gait, aimless rushing about, prostration, spasmodic or convulsive movements of the limbs, drawing of the head backward or to either side, and paralysis of one or all limbs or other parts of the body. The disease may last for several days, usually resulting in death.

Post-mortem appearance.—Congestion, pus areas, or exudates may be found at some point of the brain or cord, or they may not be visible to the naked eye. Other diseased conditions of the body which have led to meningitis may be observed.

Treatment.—Treatment is futile. The practice of antiseptic measures in docking and castrating will do much to prevent infection from this source.

PARALYSIS.

Paralysis is a loss of motion or sensation in a part of the body and generally depends upon brain or nerve derangement. Commonly, however, the term is used to express lack of movement, whether due to absence of nerve control, to extreme weakness, or to disinclination to move as a result of pain.

Cause.—True paralysis in the sheep is present in the late stages of rabies, in parturient paralysis or milk fever, in meningitis, and in gid. Conditions resembling paralysis are found in a number of the infectious and noninfectious diseases.

Treatment.—Treatment depends upon the cause and follows the lines indicated for the diseases with which it is associated.

DISEASES OF THE URINARY SYSTEM.

BLOODY URINE.

(Hematuria.)

Cause.—Reddish urine may be a symptom of several diseases, such as anthrax, hemorrhagic septicemia, icterohematuria, inflammation of the kidneys or bladder, and urinary calculi (stones). It may also follow the eating of frozen feed or poisonous plants.

Treatment.—The condition which causes a reddening of the urine should be discovered, if possible, and treated.

UREMIA.

In cases of uremia toxic substances which should be excreted with the urine are retained in the blood.

Cause.—It usually depends on retention of urine in the bladder as a result of paralysis of the bladder in connection with other diseases or when urinary calculi are lodged in the urethra. Males are more subject to stoppage of the urethra with calculi and hence more often show uremia than females. Rupture of the bladder and diseases of the kidneys also cause the disease.

Symptoms.—In the early stages there are frequent attempts to pass urine. Later, in acute cases, there is staggering gait, dizziness, and stupor, leading to unconsciousness; there are also muscular tremors and uremic convulsions. The breath smells of urine. Meat of animals slaughtered when suffering from uremia has a urinous odor.

Treatment.—The urine should be withdrawn by means of a small catheter, or, in the case of males, urinary calculi should be removed by cutting off the S-shaped tube at the end of the penis, in which the calculi are generally lodged.

GRAVEL.

(Urinary calculi.)

Cause.—Rams and wethers suffer from obstruction of the urinary passage with small bodies made up of mineral salts. Extensive feeding on turnips, sugar beets, or mangles, or feeds rich in lime salts, cause urinary calculi.

Symptoms.—The common symptoms are restlessness and frequent straining to urinate, also distention of the bladder, shown by swelling of the belly (water belly). The calculi are usually near the end of the penis, which is partly protruded.

Treatment.—The S-shaped, free end of the urethra at the end of the penis may be amputated to remove the calculi and to allow the urine to flow freely. If the obstruction is further back, a more difficult operation is necessary.

DISEASES OF THE REPRODUCTIVE SYSTEM.

ABORTION.

Cause.—Abortion in ewes may be due to a variety of causes. It may result when the animal is affected with a febrile disease; from feed containing molds, such as ergot; from being frightened or run by dogs; or from rough handling or injury. It apparently occurs also in some flocks as a specific infection due to abortion-producing microorganisms.

Symptoms.—The animal about to abort is restless, bleats constantly, and has an offensive, glairy discharge from the vagina. The lamb is usually expelled dead or dies in a short time. A portion of afterbirth may hang from the genital opening. In infectious abortion the ewe has a severe diarrhea, a putrid, dark discharge from the vagina, and a necrotic afterbirth hanging from the vulva.

Treatment.—When several cases occur about the same time and no evidence of disease or injury is apparent the feed should be examined or changed. The genital passages may be washed out with compound solution of cresol in one-fourth of 1 per cent solution, or carbolic acid in 1 per cent solution daily until the discharge ceases. Retained afterbirth should be removed if it does not come away in a day or two. The hand, instrument, and genital parts should be well disinfected before removal is attempted. Where abortions in the flock occur frequently and symptoms suggest infectious abortion, all aborting animals should be removed and the fetuses and afterbirths destroyed. Liming the soiled areas or disinfection of pens is of great importance in preventing the spread of infection.

DEATH OF FETUS IN WOMB.

Death of the fetus in the womb may be manifested by metritis (inflammation of the womb) accompanied with a purulent discharge, or no external symptoms may be shown, and the fetus dries up or becomes mummified. In the former case the treatment as given for metritis is indicated. In the latter case the udder is milked out to guard against mammitis and the animal is fattened for slaughter.

EVERSION OF UTERUS AND VAGINA.

Causes.—Protrusion of the genital organs through the vulva may result from violent spasms of the uterus, severe straining, or from forcible extraction of the lamb.

Treatment.—The parts should be thoroughly cleaned, washed with a 2 per cent carbolic-acid solution, and, after the fetal membranes are removed, gently forced back through the vagina. Sutures through the skin on each side of the vagina and passing over the opening will prevent a recurrence. If badly inflamed or gangrenous, the parts may be removed by proper surgical methods.

DYSTOCIA.

(Difficult lambing.)

The condition known as dystocia should be handled by a veterinarian or one thoroughly acquainted with the anatomy of the genital organs and the various positions which fetuses assume in presentation for birth. It is seen most frequently in ewes when they lamb for the first time. Parts of each of twin lambs entering the pelvic cavity at the same time are often responsible. When the head or legs are not presented in a normal manner or when the fetus is malformed dystocia is evident.

Treatment.—The ewe should be held and her genital passage and the hand of the operator lubricated with linseed oil. The fetus is pushed back into the uterus and rotated into position for normal presentation. A cord is passed over the feet, either fore or hind, according to the position of the fetus, and moderate traction applied as an aid to the efforts of the ewe. In assisting the ewe to pass the lamb care should be taken to see that the hands and instruments are disinfected and that no injury is done to the genital passage.

METRITIS.

(Inflammation of the womb.)

Inflammation of the generative organs of the ewe is nearly always of the septic form, runs a rapid course, and is generally fatal.

Cause.—It may occur after abortion or after normal birth, but usually follows difficult labor and forcible removal of the fetus. Injuries or tears of the uterus or vagina become infected by microorganisms and a septic condition is set up. Retained afterbirth or a dead fetus in the womb decomposes and sets up metritis.

Symptoms.—The ewe shows weakness, prostration, and distention of the rumen. There is frequent straining and a discharge from the vagina. If the animal survives the acute form, a chronic discharge may continue. Ascites (abdominal dropsy) is often present.

Treatment.—Treatment of septic metritis is not satisfactory. Early flushing of the uterus with mild antiseptics, such as hydrogen peroxid (5 per cent) or carbolic acid (1 per cent) is very important. A retained membrane or fetus should be removed by a veterinarian. Since infection may be carried from an infected to a healthy ewe, the operator should disinfect well before handling another animal.

PREPARTURIENT PARALYSIS.

(Before-lambing paralysis.)

The disease known as preparturient paralysis occurs in pregnant ewes shortly before lambing. It is not common in range sheep, but is often seen in sheep on farms where high feeding and failure to give the ewes space enough for exercise before parturition brings on excessive fatness.

Cause.—Too much rich or concentrated feed, without exercise enough to use up the excessive accumulation of food material in the body and stimulate the throwing off of poisonous body products, predisposes the animal to preparturient paralysis. Twin lambs are often responsible for the condition.

Symptoms.—In the most violent cases the ewe, without showing any earlier symptoms, falls insensible and dies in a short time with or without convulsions. In the more common form, which may last four or five days or longer, there is first seen twitching of the muscles of the hind parts and ears, loss of appetite, weakness, staggering gait, stupor, and a dark discharge from the vagina. Lambing may take place and the animal may recover, followed by the shedding of wool. In other cases severe prostration is observed, the lamb may be expelled dead, the ewe becomes completely insensible, and death follows.

Treatment.—Proper feeding and provision for exercise for some time before the lambing period will guard against this condition. Affected ewes should be given 6 ounces of Epsom salt as soon as symptoms are noticed, or if the animal is not too weak, from 5 to 10 drops of croton oil in a tablespoonful of linseed oil. Stimulants, such as strong coffee, may be given frequently.

MILK FEVER OF EWES.

(After-lambing paralysis, eclampsia.)

Milk fever of ewes is characterized by paralysis shortly after lambing.

Cause.—The cause of milk fever is not known, but it is thought to be due to toxins which develop in the udders of animals which are heavily fed and show heavy milk production at the time of lambing.

Symptoms.—Within a day or two after giving birth the ewe shows a loss of appetite, restlessness, weakness, and falls to the ground, lying in a comatose condition as if paralyzed. In favorable cases recovery takes place rapidly. In unfavorable cases death may follow in a short time. The disease is sometimes brought on by the death of the lamb or by its being taken away from the mother.

Treatment.—The injection of air into the udder through the teats effects a cure. This may be done by means of a syringe, or by a hard-rubber bulb applied over the opening in the teat.

MAMMITIS.

(Blue bag, garget, caked udder.)

Mammitis is an inflammatory disease of the udder and is frequent in ewes suckling young. It may occur in a mild or in a gangrenous form.

Cause.—It is generally due to the action of microorganisms which multiply in the milk and tissues of the udder and set up inflammatory changes. Secondary influences, such as injuries, the loss of the young with consequent accumulation of milk in the udder, or systemic derangements favor the development of disease germs.

Symptoms.—One-half of the udder or the whole udder may be affected. The part is hot, swollen, and doughy, or hard. There is restlessness and pain when suckled. The milk secretion becomes thick, yellowish, and at times bloodstained. Gangrene of the udder, with bluish discoloration, may ensue.

Treatment.—The animal should be removed from the flock. The udder should be milked frequently and hot applications made; also the part should be rubbed well or massaged. Turpentine liniment or tincture of iodin may be applied. Badly abscessed udders may be lanced, or the udder may be removed by a veterinarian. Animals which recover are usually fattened for slaughter.

REVIVING CHILLED LAMBS.

In case of twins the first born may become chilled before the ewe has time to lick it dry or suckle it. Newborn lambs frequently become chilled through inattention in cold weather.

Comfortable lambing barns should be provided. Chilled lambs may be placed in warm quarters, wrapped in blankets, or the body may be immersed in a tub of warm water. When revived the lamb is wiped dry and given to its mother or held at her side until it has suckled.

DISEASES OF THE SKIN.

ECZEMA.

(Rain rot, greasy heel.)

Eczema is a disease of the skin characterized by congestion, exudation, and itching.

Cause.—The most important form of eczema is found in loose-wooled sheep and affects principally the back, loins, and croup. It results when the animal gets wet to the skin in cold, damp weather. Continued dampness of the skin sets up an inflammation. This condition is known as fat scab or rain rot.

Greasy heel occurring on the fetlocks, and eczema between the claws, are seen in sheep kept in damp or dirty places.

Solar eczema results from exposure to the sun soon after shearing.

Irritants on the skin, such as strong sheep dips, may cause eczema.

Symptoms.—The skin is swollen, cracked in spots, reddened, and covered with a moist exudate which dries and forms scabs. Itching is present. Patches of wool fall out.

Treatment.—Recovery takes place in a short time when the conditions which bring on eczema are removed. Rain rot disappears in dry weather.

RINGWORM.

Ringworm is an infectious skin disease which, in sheep, is not very often seen in the United States.

Cause.—It is caused by a fungus, *Trichophyton tonsurans*, which grows around the roots of the wool and forms an enormous number of spores (seeds). The disease when once in a flock may be transferred from one animal to another by direct contact or by rubbing posts.

Symptoms.—Small circular spots covered by a grayish-white crust appear on the back, neck, face, chest, or shoulder. They may be detected by the matting of the wool into small tufts which stand out prominently. Itching is severe and the animal rubs the affected parts. The skin is reddened. Ringworm areas may extend, unite, and lead to baldness.

Treatment.—Diseased animals should be isolated as soon as symptoms are noticed, and pens or rubbing places should be disinfected. Shear the affected regions. Soften the ringworm crusts with the aid of soft soap or an oily substance and remove them. Apply an ointment of cresol or carbolic acid 1 part and lanolin or vaseline 10 parts; tincture of iodin may be substituted. Applications should be repeated daily until healing is effected.

BUCKWHEAT RASH.

(Fagopyrism.)

A mild or severe inflammation of the skin of white sheep is associated with the feeding of buckwheat and exposure to direct sunlight. Black sheep or black areas on white sheep are not affected. This disease is reported from Europe but closely resembles bighead in American sheep.

Cause.—The green flowering buckwheat plant is more active than either the grain or dried plant. Exposure to direct sunlight within a few days after eating buckwheat is necessary to production of the rash.

Symptoms.—In mild cases the skin is reddened, slightly swollen, and itches. Recovery takes place in a day or two, leaving a brownish discoloration of the skin.

In severe cases the affected skin is deeply reddened, considerably swollen, and the itching is intense. Vesicles form, rupture, and leave crusts. The head may be badly swollen and the ears drooped. The animal runs about wildly. In fatal cases death occurs after 10 or 12 hours. Otherwise the animal recovers within a few days.

Treatment.—Give from 2 to 4 ounces of castor oil. Stop feeding buckwheat. Keep the animals under cover or in a shady place for a few days when the sun's rays are intense. Olive oil, cottonseed oil, or vaseline should be rubbed over the affected areas.

DANDRUFF.

(False scab, tallow scab.)

Whitish-yellowish or brownish-yellow greasy scales may be observed on the back, shoulders, breast, or neck. The scales consist of oily secretion and cells of the outer layer of the skin. Itching is absent, but the animal may pull wool from the affected areas.

Cause.—Frequently no cause is apparent, but animals in poor concondition or suffering from other ailments are most often affected.

Treatment.—The disease is not of common occurrence and is of small importance. Good nourishment and care of the skin generally correct the disorder.

BALDNESS.

(Alopecia, falling out of the wool.)

Baldness is observed as a symptom or as a result of several diseases, namely, scab, blue bag, metritis, eczema, ringworm, or dandruff. Its control rests upon the proper treatment of the disease from which it results.

INFECTIOUS and noninfectious diseases and common ailments of sheep in America are considered in this bulletin. It does not deal with diseases caused by animal parasites, such as gid, grub in the head, stomach, lung, and intestinal-worm affections, liver rot, scabies, etc., nor with plant poisoning. These diseases are described in other publications of the Department of Agriculture.

The aim has been to give only the more important or characteristic symptoms which would be of value in distinguishing one disease from another.

Sheep owners are reminded that a disease does not always display identical symptoms in each animal, and also that certain general symptoms may be present in a number of diseases. Hence in important cases it is advisable to call in a veterinarian, if one is available, rather than trust too much to one's own powers of observation.

Methods of treatment are outlined with regard to ease of application and the use of remedies which are both effective and easily procured.

Much may be done to prevent disease and to keep sheep in a healthy condition by proper care, feeding, and sanitation. Information as to disinfection and disinfectants may be found in Farmers' Bulletins 926 and 954.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

UNITED STATES DEPARTMENT OF AGRICULTURE

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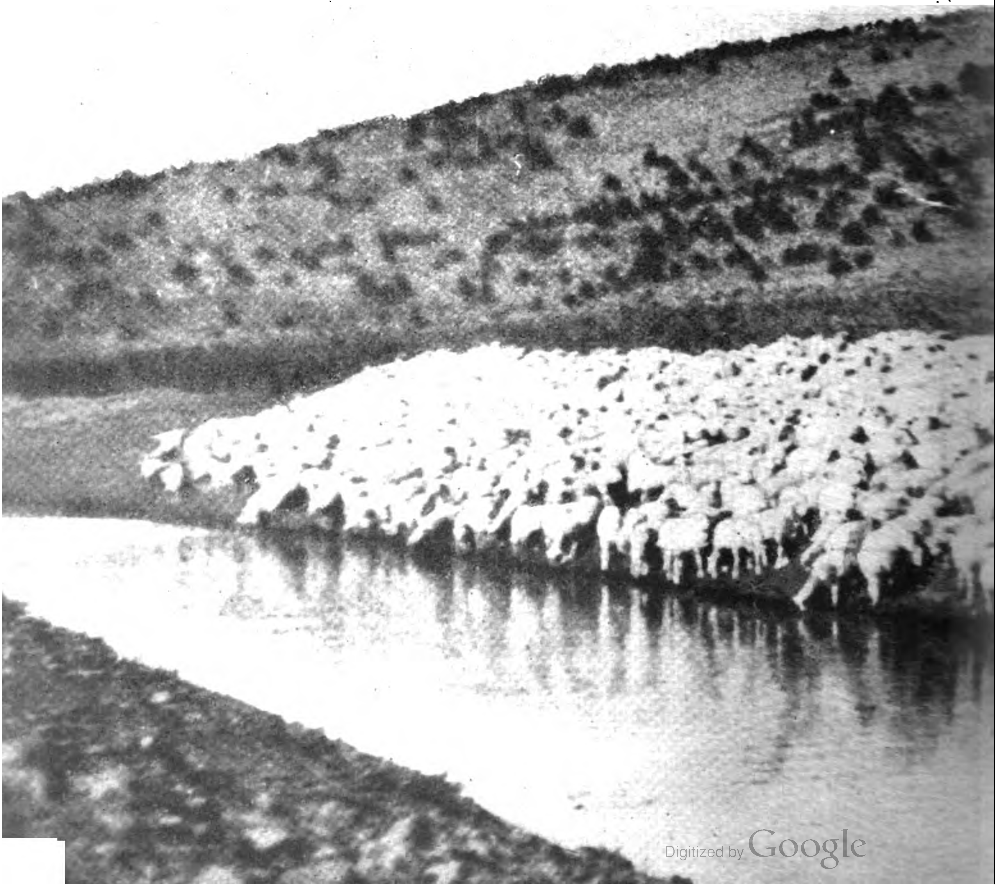

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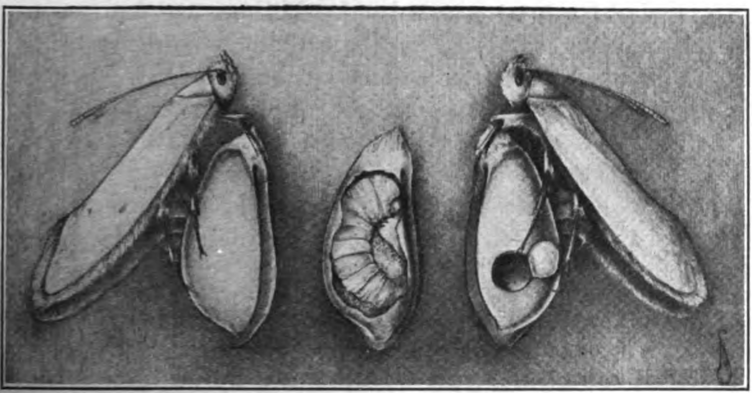
ANGOUMOIS GRAIN MOTH

E. A. BACK

Entomologist in Charge, Stored Product Insect Investigations



UNIVERSITY

FARMERS' BULLETIN 1156

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. September, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 19

THE ANGOUMOIS grain moth, primarily a pest of wheat and corn in this country, attacks all cereal grains. It is particularly injurious throughout the Southern States. It does little harm north of central New Jersey except to cereals in storage.

It is second to the rice or "black" weevil in its capacity to damage grain. Often entire crops of corn and wheat are ruined. Millers are known to have refused to buy badly affected crops, as flour made from damaged wheat is not fit to eat. Wheat loses through moth attack about 52 per cent in weight. Corn, being larger, loses from 12 to 24 per cent in weight when kernels are attacked by a single insect only. As many as three or four moths, however, may develop in one corn kernel. The feeding of a single insect will completely ruin so small a grain as milo or sorghum.

Farmers suffer losses unnecessarily. Losses can be prevented by watchfulness and by application of measures advocated in this bulletin. Choose between prompt harvesting, early thrashing or shucking, proper storage, and little loss, and delayed harvesting, delayed thrashing.in case of wheat, careless or improper storage, and large losses. Well-informed farmers are storing corn and wheat without loss by giving attention to cultural methods and treatment in storage by fumigation. Where one succeeds, all can.

All farmers can support campaigns to kill out the Angoumois grain moth. No pest can be controlled more effectively. If county agents will unite farmers to fight this pest they will save their counties grain worth many times the salaries paid them. Success awaits intelligent action.

ANGOUMOIS GRAIN MOTH.[1]

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ESTABLISHMENT AND SPREAD IN AMERICA.

The Angoumois grain moth is a European pest that has become destructive to corn, wheat, and other grains in this country as a result of international commerce. It is called the Angoumois grain moth because long before the early days of the American Republic it had been a pest in the Angoumois Province of France. It is known also in America by the popular name of "fly weevil."

In the early days of American history there was no Federal Horticultural Board to protect our agriculture from foreign pests. The Angoumois grain moth is one of those pests that are easily carried in grain from place to place. It was brought many times to this country in seed introduced from Europe by the earlier settlers of the various colonies along the Atlantic seaboard. Since it is a pest that is easily killed out by very cold winters, it is natural that its establishment in this country occurred in one of the Southern States. The first report of the occurrence of the Angoumois grain moth in this country was in 1728, in North Carolina, where it was causing damage to wheat. It was first reported in Maryland about 1769. Between 1728 and 1775 it had spread northward into Virginia, Maryland, lower Delaware, and probably southern New Jersey. In 1852 Harris wrote that wheat in Kentucky and in the southern parts of Ohio and Indiana was already affected. Though exact records of spread are not available, it is enough to know that from the original North Carolina-Virginia infestation the Angoumois grain moth has spread, chiefly through the shipment of seeds,

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[1] *Sitotroga cerealella* Oliv.

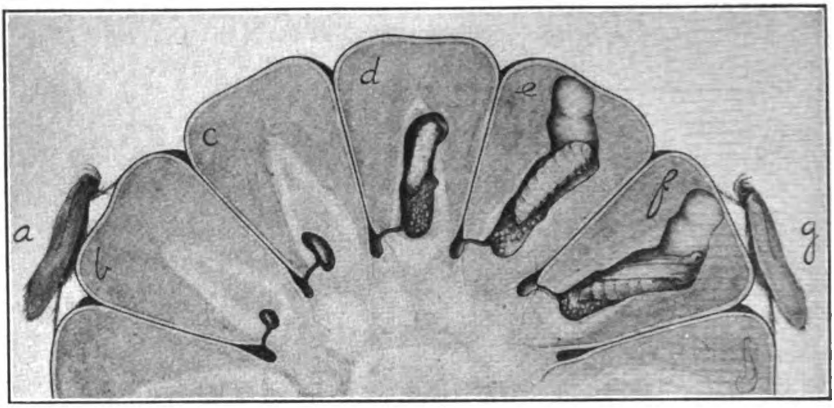

FIG. 1.—Life cycle of the Angoumois grain moth in corn. The adult moth is shown at *a* and *g*. The larva is shown in different stages of its growth at *b*, *c*, *d*, and *e*. Notice that it begins feeding at the soft germ end of the seed and as it becomes larger eats out into the harder part of the corn. The larva transforms to the pupa as shown at *f*. From the pupa develops the adult moth *g* of the second generation.

southward through all the Southern States and northward. The farther South it has spread the more destructive it has become, because it can multiply unhampered by long, cold winters. On the other hand, its spread northward has been limited by increasingly cold winter weather.

While the moth causes much injury to the wheat crops in the southern parts of the North Central States and New Jersey, Delaware, southeastern Pennsylvania, Maryland, and Virginia, crops grown still farther north are increasingly immune to attack in the field. After one passes the fortieth degree of north latitude injury from the Angoumois grain moth decreases rapidly. Because of the ease with which it can be carried in seeds the Angoumois grain moth is now and then reported from all States, even those possessing a climate far too cold to permit it to become a general pest.

DESCRIPTION.

The Angoumois grain moth passes through the usual insect stages—the parent insect or moth, the egg, the larva, and the pupa. The moth is shown in figures 1, 8, 11, and on title page. It varies somewhat in color from buff to grayish or yellowish brown. In size it varies with the size of the grain in which it matures, but is never more than 0.6 to 0.7 of an inch from tip to tip of wings when these are spread as shown in figure 8. The average wing spread of the moth is about one-half inch. Whenever moths of this size, closely resembling ordinary clothes moths, are seen flying about grain it is reasonably certain that the grain is infested with the Angoumois grain moth. The eggs laid by the moth are about one-fortieth of an inch long and are too small to be seen without the aid of a magnifying glass. They are laid on or near the grain. They are white when first deposited, but later turn a reddish color before the larva or grub hatches. A moth may lay as many as 150 eggs. An egg is shown in figure 8, *b*. The larva is shown in figures 1, 8, and on title page. When just hatched the larva is tiny, being no thicker than a hair. After feeding in the grain it becomes full grown and is then about one-fifth of an inch long, white in color, with a yellowish-brown head. The pupa or chrysalis is reddish brown and is shown in figures 1, 5, and 8.

INJURY.

Injury to grains by the Angoumois grain moth always takes place in the larval stage. Injury is more difficult to detect in the early stages of infestation because the grub or larva bores its way into the seeds when it is so small that the hole by which it enters can not be found without a close search with a magnifying glass. Usually after it has eaten its way into the seed, the larva turns about and spins a silken web over the opening by which it has entered, thus making it even more difficult to locate the entrance hole. Once within the seed, the grub eats out the interior where it feeds unseen and often unsuspected by the owner of the grain. Usually the first indication the average grower has that his grain is infested is the simultaneous appearance of moths and the round holes (figs. 2, 5, 7, 8, and 9) that appear in the individual kernels, or sometimes by the heating of the grain in the bin. Then he finds upon cutting open the seeds in which the holes have appeared that they have been hollowed out by the larva (figs. 1, 4, 5, and 8) and that his grain has not only lost heavily in weight but that it contains much excrement and webbing left behind by the insect. The larva has jaws called mandibles, and it uses them almost

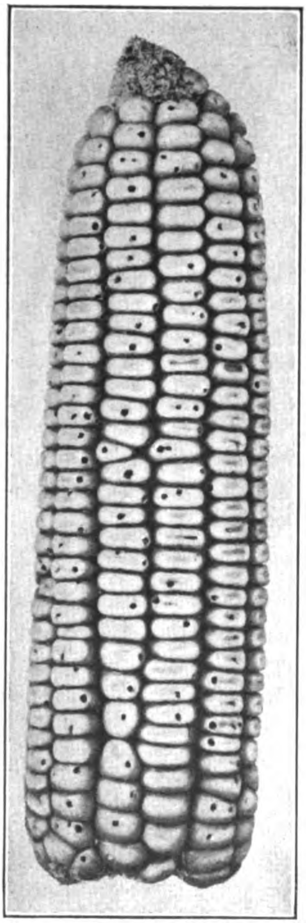

FIG. 2.—An ear of corn showing the emergence holes of the Angoumois grain moth. When these holes begin to appear in your corn and small clothes-moth-like millers are found flying when the corn is disturbed, you may be certain that the Angoumois grain moth is already damaging your corn.

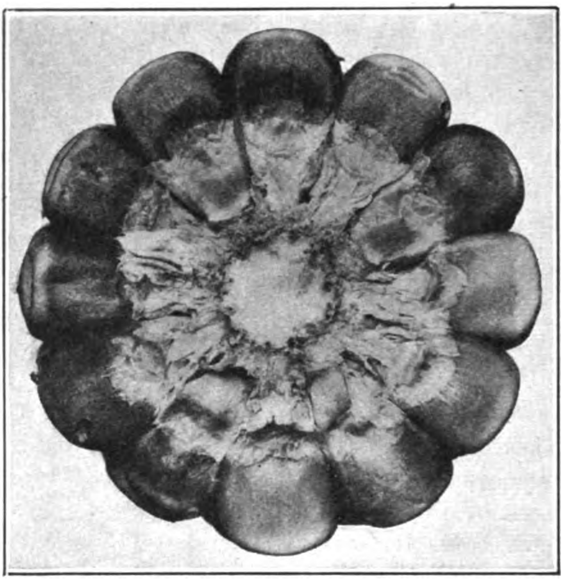

FIG. 3.—An ear of corn badly damaged by the Angoumois grain moth, broken in two to show how perfect the kernels may appear when viewed from the side.

continuously, first to gnaw its way into the seed and then to eat out the contents of the seeds to secure nourishment for its growth and to make the circular opening through which the moth itself emerges from the seed. The circular opening is not cut until the larva has become full grown. It then eats out a channel to the outside of the seed, leaving the merest film of the seed coat intact. The moth is strong enough to push off this "cap" when it leaves the seed. The opening is often called the emergence hole.

TIME REQUIRED FOR DEVELOPMENT.

Under ordinary atmospheric conditions, temperature has everything to do with the development of the Angoumois grain moth. All eggs, larvæ, pupæ, and adult moths are killed if the grain is heated throughout to a temperature of 120° F. Exposure of the eggs to a temperature of 1° F. for 24 hours has prevented their hatching. Ordinary winter storage temperatures below 60° F. in regions where the moth is a real pest will hold the moth in a quiescent or dormant state, but will not kill. Development goes on slowly between 60° and 70° F., and very rapidly between 70° and 95° F. It does not matter whether these temperatures obtain indoors or out of doors. This explains how the Angoumois grain moth can breed generation after generation in warehouses or rooms kept at a moderately high temperature in a cold climate with outdoor temperatures too low for the moth.

Experimental work has not determined the developmental period of the Angoumois grain moth for various temperatures. The eggs will hatch during the heat of summer in from 7 to 10 days. Eggs may not hatch in colder weather in 3 or 4 weeks. In general, the life cycle representing one generation from egg to adult requires in warm summer weather from 5 to 7 weeks, though the immature stages have been passed in as few as 4 weeks. During the cold of winter months the larva lies dormant for 4 or 5 months and the life cycle may be fully 6 months long. In the southern wheat belt of New Jersey there may be five generations of moths in a year under prevailing cultural conditions where wheat is left in the field until late in the season. The farther south one goes the greater is the number of generations, and in heated warehouses or rooms there may be as many as 10 to 12 generations.

ALL CEREAL GRAINS AFFECTED.

The Angoumois grain moth has been bred from wheat, barley, oats, buckwheat, corn, sorghum, milo, rice, beans, chickpeas, and cowpeas. It is a general feeder upon seeds of the cereal type. It causes greatest loss to wheat and corn in this country, though instances of serious attack are recorded frequently upon other grains. Beans, chickpeas, and cowpeas usually are not attacked, though if held in storage for considerable periods the Angoumois grain moth has been known to cause much damage, particularly in seeds already slightly injured by han-

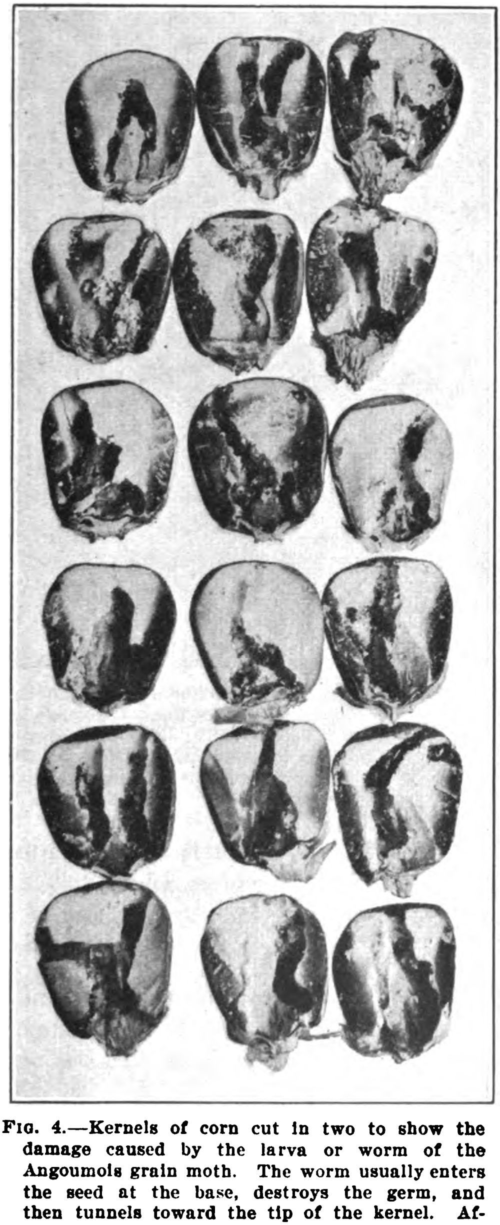

FIG. 4.—Kernels of corn cut in two to show the damage caused by the larva or worm of the Angoumois grain moth. The worm usually enters the seed at the base, destroys the germ, and then tunnels toward the tip of the kernel. Affected kernels nearly always are ruined for planting purposes.

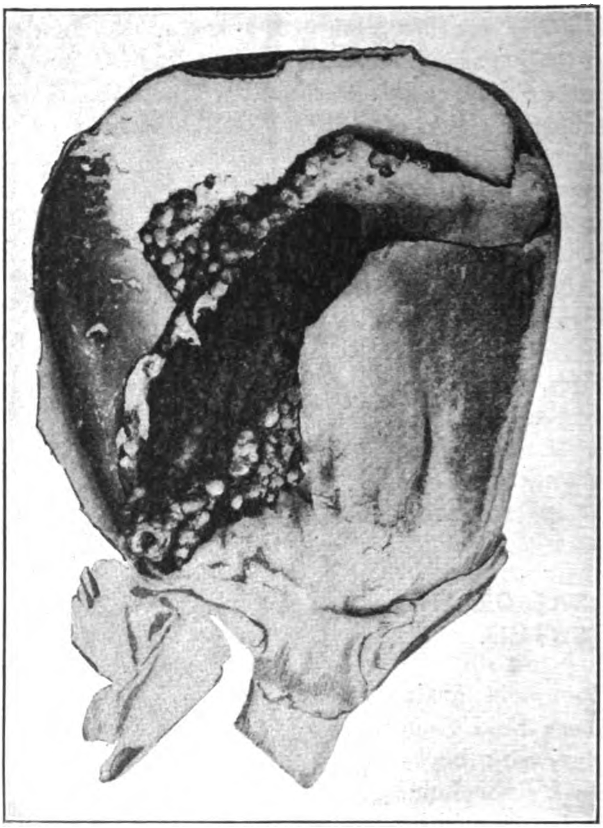

FIG. 5.—Cross section of one of the kernels of corn in figure 3, enlarged to show the cavity made by the larva of the Angoumois grain moth, the silken chamber formed by the larva, before transforming to the pupa. The large brown or blackish appearing object is the pupa from which the moth will emerge and crawl along the silken channel in escaping from the seed.

dling or by bean weevil attack. Rice handled under commercial conditions is very seldom affected.

LOSSES.

It is difficult to estimate the amount of loss caused grain growers, dealers, and millers by the Angoumois grain moth. Throughout the extreme South it is rated as a pest second only to the rice or "black" weevil.[2]

Throughout the wheat belt of Southeastern Pennsylvania, New Jersey, Delaware, and Virginia, it is the worst pest of ripening wheat and wheat in storage. Many crops have suffered a loss of 10

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[2] *Calandra oryza* L.

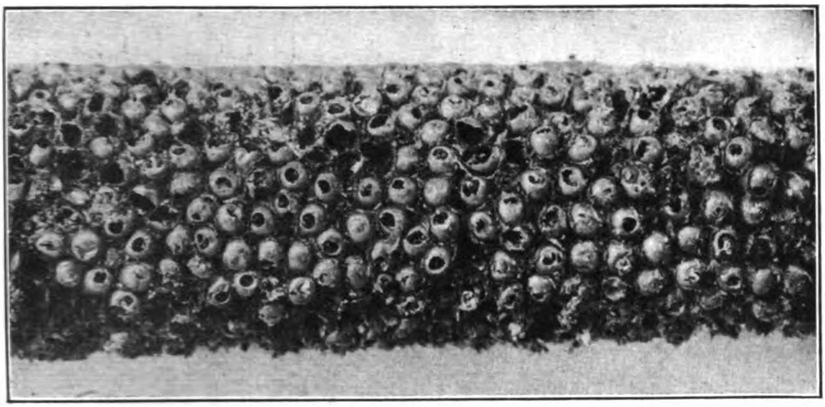


FIG. 6.—A spike of sorghum with each seed showing the emergence hole of the Angoumois grain moth. The moth completely ruins so small a seed as this.

to 60 per cent. Millers have not infrequently refused to purchase badly damaged grains because they contained so many dead insects and insect excrement. Flour made of badly infested seeds is not palatable. The actual weighing of 1,000 kernels of sound wheat and a like number of infested kernels showed a loss by weight of 56.2 per cent as a result of the development of a single moth in each of the infested kernels. (Fig. 9.)

Corn does not lose so great a percentage of its weight. The weights of an equal number of infested and perfect kernels representing seven varieties of soft dent and flint corn showed that where but one moth had developed in each infested kernel the infestation had caused a loss in weight amounting to 13.1, 13.2, 15.5, 17.3, 19.7, 23.5, and 24 per cent, respectively. The loss in weight varies with the ratio between the size of the kernel and the amount eaten by the individual insect in reaching its maturity.

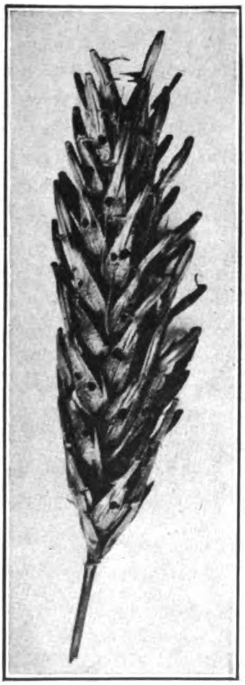
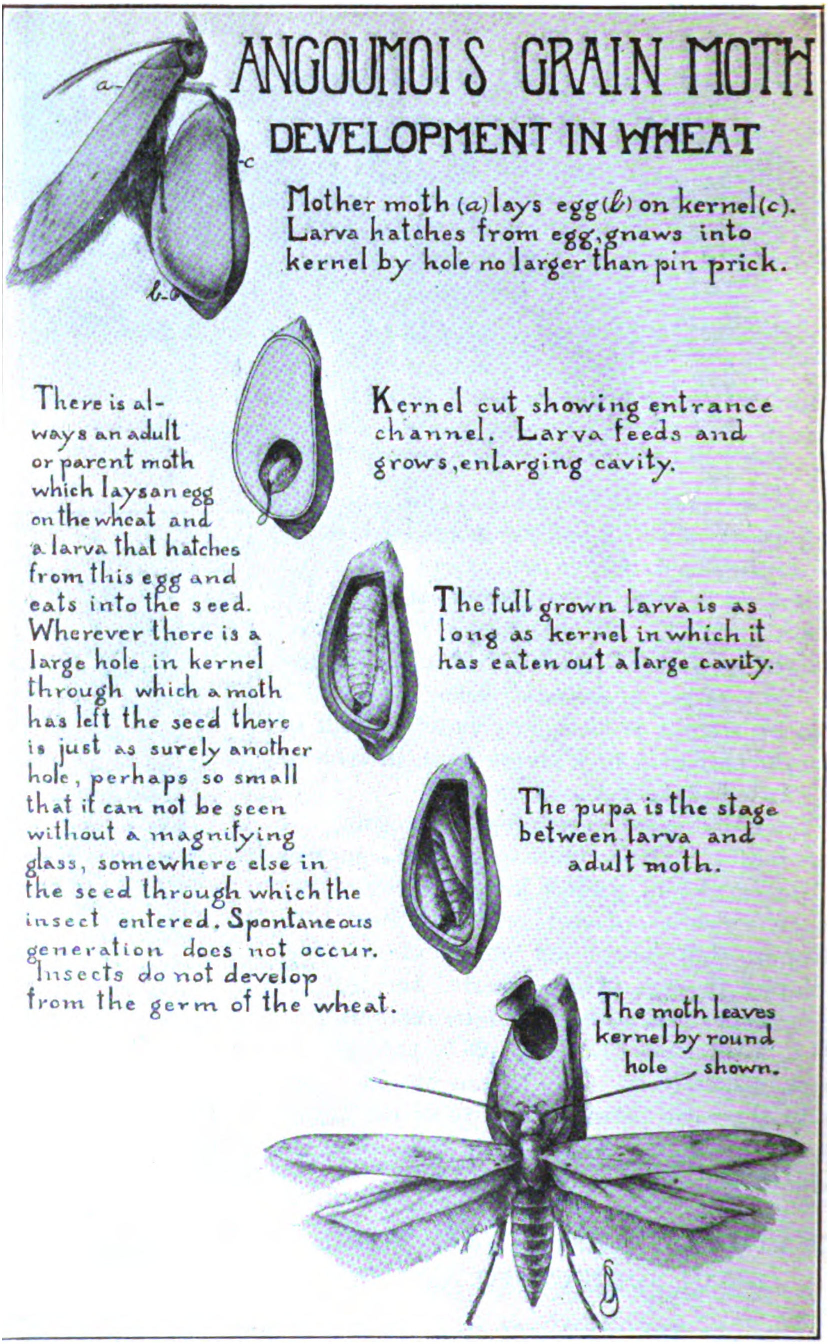


FIG. 7.—A head of beardless barley showing the emergence holes of the Angoumois grain moth. Remember that unthrashed wheat, rye, oats, or barley are not at all protected from the moth.

MATURING GRAIN AND STORED GRAIN SUBJECT TO ATTACK.

The Angoumois grain moth feeds both in dried grains in storage and in grains matur-



ANGOUMOIS GRAIN MOTH

DEVELOPMENT IN WHEAT

Mother moth (a) lays egg (b) on kernel (c). Larva hatches from egg, gnaws into kernel by hole no larger than pin prick.

Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.

There is always an adult or parent moth which lays an egg on the wheat and a larva that hatches from this egg and eats into the seed. Wherever there is a large hole in kernel through which a moth has left the seed there is just as surely another hole, perhaps so small that it can not be seen without a magnifying glass, somewhere else in the seed through which the insect entered. Spontaneous generation does not occur. Insects do not develop from the germ of the wheat.

The full grown larva is as long as kernel in which it has eaten out a large cavity.

The pupa is the stage between larva and adult moth.

The moth leaves kernel by round hole shown.

FIG. 8.—Development of Angoumois grain moth on wheat. Life cycle.

ing in the field. In storage the pest breeds generation after generation as long as the food supply lasts. This may be several years in what are commonly believed to be "air-tight" containers. In agricultural districts, especially where the pest is breeding in storage in open bins or mows, the moth is driven by instinct to leave the warehouse, barn, or crib in varying numbers and fly to the near-by fields in search of maturing grains in which to lay eggs for the first summer generation in the field. Of course many remain behind in the crib to multiply continuously throughout the year.

INFESTATION OF CORN.

Corn has an advantage over the smaller grains in that most of the kernels are covered during growth by the husk covering. It has already been pointed out that destruction by the Angoumois grain moth takes place in the larval stage. The parent which flies from grain in storage to the field to start the first generation in maturing grain can not eat into the shuck covering. Hence corn protected by a well-developed, uninjured shuck covering is never affected. But where the shuck is either loosely developed at the tip or damaged by smut, corn earworm,[3] or other insects, the moth can easily reach the kernels and lay her eggs upon them, thus starting an infestation.

These relatively few cases of infestation in the field serve as centers of infestation from which following generations of moths maturing in standing corn or corn shocked in the field, or corn that has been placed in the crib, will spread in large numbers and bring about a general infestation of the entire lot of corn in storage. There is practically no infestation of corn in the field except in the more southern States. As far north as Maryland instances of field infestation are very rare and there is little danger of infestation where corn is stored in ordinary slatted cribs until the coming of warm weather of the following summer. But in the Gulf Coast States, especially when the corn is growing on poor land, where shuck

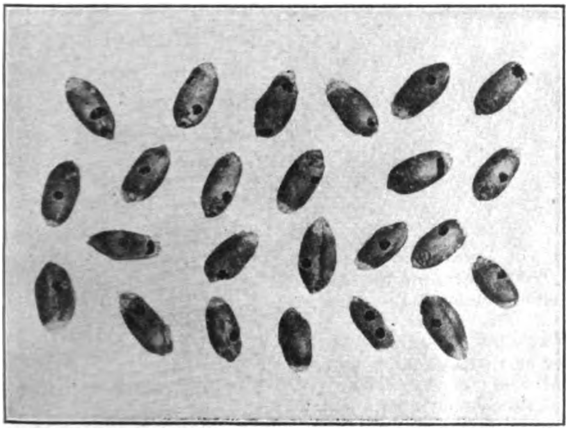


FIG. 9.—Kernels of wheat showing the small round emergence holes that prove that an Angoumois grain moth has developed in the seed, thus reducing its weight somewhat over 50 per cent.

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[3] *Chloridea obsoleta* Fab.

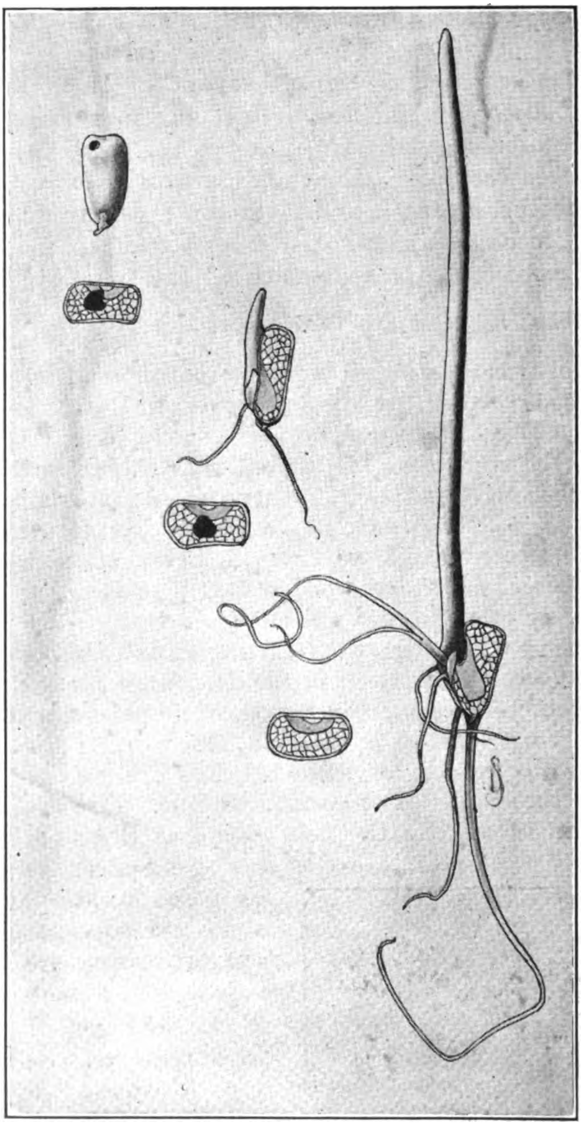

FIG. 10.—Three kernels of corn, the lowest one free from attack and sprouting normally. The larva of the Angoumois grain moth has completely destroyed the germ of the upper kernel and it has failed to sprout. The germ of the middle kernel has been affected but slightly by the developing moth yet notice how small its shoot is as compared with that of the normal seed; it will die or produce a sickly plant. Do not plant seed infested with the Angoumois grain moth.

development is poorest, the infestation of maturing ears may be very general and result in heavy losses in storage.

Figures 1 to 5 and 10 illustrate the manner in which corn is injured. The moth lays her eggs usually between the kernels on the cob. On shelled corn the eggs may be laid anywhere. The newly hatched larva usually crawls to the germ end of the seed, bores in through the seed coat, which is there more tender, and thus finds itself in the softest part of the kernel. From the illustrations it will be seen that the larva usually eats out and destroys the embryo or germ of the seed, and then bores its way outward into the harder part of the seed (figs. 1 and 4). More often the emergence hole is found on the outer portion of the kernel, though this is not always so. Ordinarily, development occurs entirely within a single kernel, yet the larva may begin its feeding in one kernel and finish it in the adjoining one. In some varieties of corn many larvæ form their emergence holes at the base of the kernel, so that the moth in attempting to escape from the kernel finds itself wedged in by the surrounding kernels and forced to starve, since only the larva of the moth can feed on grain. Although many moths in an ear may lose their lives in this way, yet enough emerge normally to cause heavy infestations.

It is interesting to record that while the young larva can not eat through corn shucks to reach the kernels, those hatching from eggs laid through breaks in the shuck covering may be so numerous, particularly in storage, that they spread to and enter nearly all the kernels on an ear, even those kernels well covered by the shuck. While the newly hatched larva can not eat through the shuck to the kernel, the mature larva, which is much stronger, may bore its way out from the kernel through the shuck covering to the exterior. Instances have been found where the larva of the Angoumois grain moth has eaten through eight and nine thicknesses of shuck covering, though ordinarily escape is not effected where there are this number of thicknesses. Infestation of kernels at the tip of an ear may take place if the silk has been eaten out, thus leaving a channel down which either the moth or the newly hatched larva can crawl. While the infestations that occur through eaten-out silk channels and through breaks in the shuck covering are not in themselves usually of importance from the standpoint of grain actually destroyed, they are of immense importance as "leaven" for the subsequent infestation of entire crops held carelessly in storage.[4]

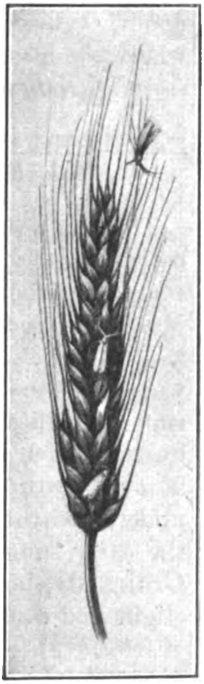

FIG. 11.—A head of maturing wheat showing three adult Angoumois grain moths that have flown from the crib to the field of ripening grain and are seeking to lay eggs upon the head.

FIELD INFESTATION OF WHEAT.

It has been stated already that the adult of the first generation of the Angoumois grain moth instinctively flies from the crib or storage house to the near-by fields of grain as the crop is approaching maturity. It also has been stated that the moth can not infest the corn if the shuck covering is well developed and uninjured. The planting of varieties of corn developing a long, tight shuck, as recommended by the department,[5] will greatly lessen moth injury in the field. But this advantage which corn has is not shared by wheat, barley, and similar small grains. The female moth upon flying from bin to field may lay from 20 to 30 eggs upon the head of wheat chosen for attack. The larvæ hatching from these eggs scatter over the head, only one entering each kernel. The thin membranes covering the kernel are no hindrance to the entrance of the larvæ. This starting of infestation in the field may take place, as King[6] has so recently proved beyond doubt, even while wheat is "in the milk." Infestations of growing wheat are most heavy nearest places where infested wheat has been stored throughout the winter and spring.

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[4] If the Angoumois grain moth were the only pest farmers had to contend with it would be better to keep corn in storage with the shucks on, as good shuck cover is a great aid to conservation of corn against this pest. Unfortunately in sections where the moth is a serious pest of corn, the corn is also attacked by the rice or "black" weevil against which shucks are of far less protection. If corn is shucked at harvest and fumigated at once, so practical experience on the southern farms is proving, losses are either greatly reduced or entirely prevented in storage.

EARLY FIELD INFESTATIONS AND DELAYED HARVESTING INCREASE OPPORTUNITY FOR DAMAGE.

There is a direct relationship overlooked by many wheat growers between early field infestation, delayed harvesting, and damage caused by the Angoumois grain moth. In southern New Jersey, Maryland, and southeastern Pennsylvania the first moths appear in the wheat fields about the time the wheat is "in the milk." In other words, the moth may begin to lay eggs in the wheat heads at any time after the kernels are well set. As each moth may live five days, during which she flies about the field laying eggs in batches of 1 to 20 or more until she has laid a total of about 150 eggs, it will be understood that a field of grain may have many heads infested by the early summer flight of moths from near-by cribs or granaries. Ordinarily, however, these first early summer infestations are very slight and cause no appreciable loss if the crop is handled correctly.

SECOND AND THIRD GENERATION IN FIELD SPREADS LIKE WILDFIRE.

The first generation of moths in the maturing heads of wheat, as just stated, usually is not a large one. But for each female moth of the first generation that reached the field in late May and June, there may be 150 moths of the second generation maturing in middle July and August. Ordinarily the moths of the second generation begin to appear soon after the grain is ready to cut, though a few may mature before the grain is ripened. The moths for the third generation appear during late August and during September. Granting that the sexes are evenly divided, for each female moth flying to the field in May or June there are about 11,250 moths, or 5,625 female moths ready to start the third generation of infestation in late August and September, and these moths are capable of laying 843,750 eggs. As only one Angoumois grain moth usually develops in a single wheat kernel, for each infested kernel in May and June there may be in late August and September 843,750 infested kernels. And if the grain is stored unthrashed in the barn where the moths can easily reach the kernels, or is left unthrashed in the field during warm weather, infestation may increase to 63,281,250 kernels in October for each infested kernel in May or June.

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[5] For further discussion of long tight shuck, see U. S. Department of Agriculture Farmers' Bulletin 915, "How to reduce weevil waste in southern corn," by C. H. Kyle.

[6] KING, J. L. THE ANGOUMOIS GRAIN MOTH. Pa. Dept. Agr., Bur. Plant Industry Circular No. 1. 14 p., 2 figs. 1920.

PROMPT THRASHING MEANS SAVING.

It is known that grain standing in the field uncut, grain stacked in the field, or mowed away unthrashed in barns, is not protected from so small an insect as the Angoumois grain moth. The moths are so small that they can crawl into unthrashed grain and lay their eggs. They prefer the more exposed outer heads but they can infest the inside heads. It is also known that the Angoumois grain moth while very small is too weak to force its way down into wheat or any grain when it is stored in bulk in large quantities. When stored in bins only the upper one or two inches of grain become infested. Since the moth is too weak to burrow down into a mass of wheat, it is also too weak to push the kernels aside and crawl to the top of the bin if it comes out of a kernel more than two or three inches below the surface of the grain.

TAKE ADVANTAGE OF THE INSECT'S WEAKNESS.

Farmers can turn this weakness to their advantage. If wheat is cut as soon as ripe, thrashed as soon as dry, and placed at once in storage in deep bins where only a relatively small surface of wheat is exposed, the Angoumois grain moth will not ordinarily cause trouble. The relatively small amount of wheat that is infested by the time wheat is ripe and can be thrashed is not great enough to cause heating in the bins as a result of moth infestation. The moths that develop in the kernels well below the top of the bin die without reproducing because they are too weak to extricate themselves. The same result is obtained when the wheat is placed in closely woven sacks that are well secured. *The early harvesting and proper storing of wheat nips in the bud the first early infestations that occur in the field, without cost or material loss to the grower.*

DELAYED THRASHING RUINS MANY CROPS.

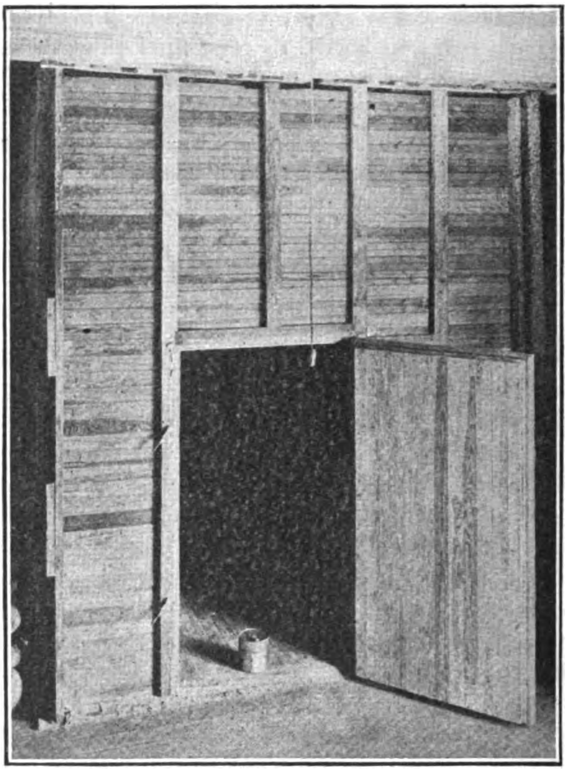

Fig. 12.—Front view of a specially constructed fumigating room used for killing insects in corn, wheat, and other substances. It is made of double thicknesses of matched boards with building paper between. Such a room is valuable in fumigating with carbon disulphid grain stored in sacks.

The greatest argument against early thrashing of wheat is the difficulty of getting a thrashing machine just when it is needed. Where a community depends upon a traveling thrashing machine, farmers must wait their turn. A period of wet weather after cutting may prevent thrashing though it does not prevent the moth from multiplying. Wet weather can not be overcome, but farmers can combine more effectively in arranging for the prompt thrashing of their wheat. The amount of wheat saved by early thrashing during occasional bad "fly weevil" years will often pay many times over for the investment required to own a thrashing machine. *The farmer can choose between prompt harvesting, early thrashing, proper storage, and little or no loss, and delayed harvesting, late thrashing, and great loss.* It will pay him to provide against loss.

REMEDIAL MEASURES.

The most satisfactory method of controlling the Angoumois grain moth attacking almost any crop, but especially wheat, is, as just stated, prompt harvesting and storing under conditions unfavorable to the moth attack. (See figs. 12–16.) The great losses that are reported throughout wheat areas affected by the pest are the result of delayed harvesting, thrashing, and storing. *The storing of wheat unthrashed in barns or stacking it unthrashed in the field increases the loss. Prompt harvesting, thrashing, and storing in deep, tight bins, or in tight sacks, is effective.* Wheat should never be left spread in thin layers on barn floors except when too wet to store. Such a practice makes it easy for the moth to lay eggs on kernels.

DRYNESS.

It is stated that where practicable to store grain under dry conditions, the amount of damage done by the Angoumois grain moth will be reduced greatly. If the atmospheric moisture can be reduced to 26 per cent or below, all infestation will be destroyed.

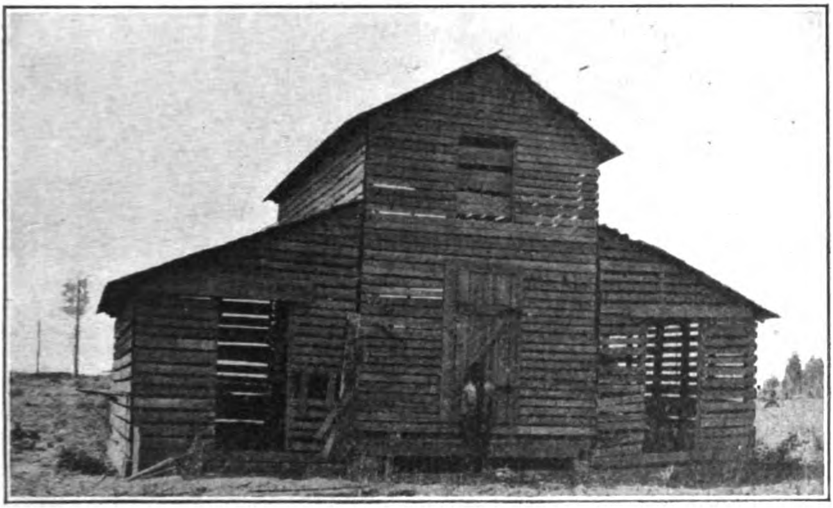

FIG. 13.—A slatted corn crib. Such corn cribs are no protection from insects to corn stored in them in the extreme South. Corn stored in slatted cribs from Maryland northward is safe from Angoumois grain moth attack at least until the summer following harvest, as the cold of winter is usually sufficient to prevent moths from surviving the winter in slatted cribs.

FUMIGATION.

If grain is found badly infested with the Angoumois grain moth it should be fanned and screened. Such treatment will remove about half of the infested kernels of wheat, but will not remove infested kernels of corn. Remember fanning only removes adult moths, débris, and light kernels. *To kill the moth in the remaining crop the seeds must be fumigated or heated. The best two fumigants are hydrocyanic-acid gas and carbon disulphid.* Hydrocyanic-acid gas is lighter than air, very deadly to man as well as insects, and

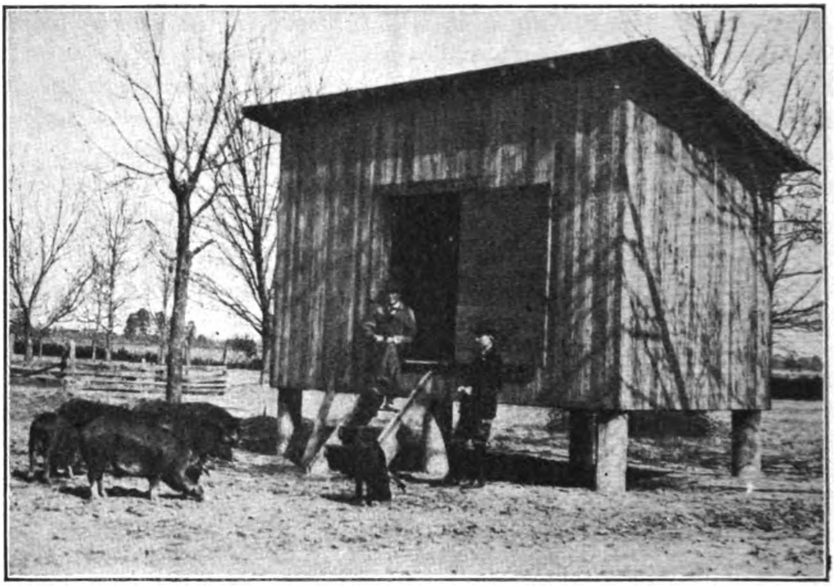

FIG. 14.—Corn crib belonging to farmer in Georgia. This was originally a slatted crib, but the weevils were so destructive that he covered it with building paper and a layer of tongue and groove boarding, made his floor tight, and fumigated with carbon disulphid. He no longer fears weevils. Anyone can make their cribs tight with the aid of the county agent.

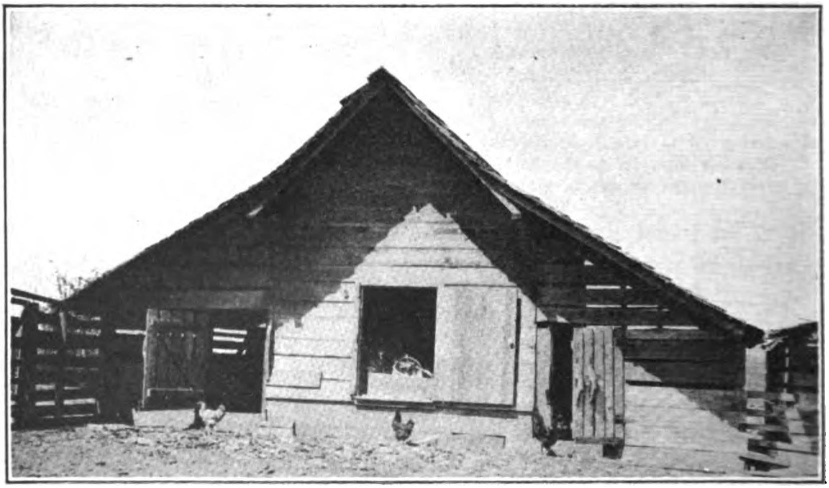

FIG. 15.—An old-style barn with lean-to sheds. The owner could not store corn or wheat and keep it free from weevils. At the advice of the county agent he sealed the barn on the inside with tongue and groove boarding, and filled the space between the rough outer boards and sealing with packed sawdust. He then fumigated with carbon disulphid and killed all weevils. Use your ingenuity to tighten your old crib or build a new one, according to the advice of your county agent.

useful in killing the moth in grain stored unthrashed. It is not recommended for the treatment of thrashed grain in bulk.

Thrashed grain in bulk should be fumigated with carbon disulphid. This gas is heavier than air and is a standard gas recommended to kill moths in grain stored in bins, tight rooms, etc. It will not injure the seed for planting if the seeds are thoroughly dried when fumigated. Information regarding hydrocyanic-acid gas and carbon disulphid is given in Farmers' Bulletins 699 and 799, which may be had free by writing to the Secretary of Agriculture, Washington, D. C.

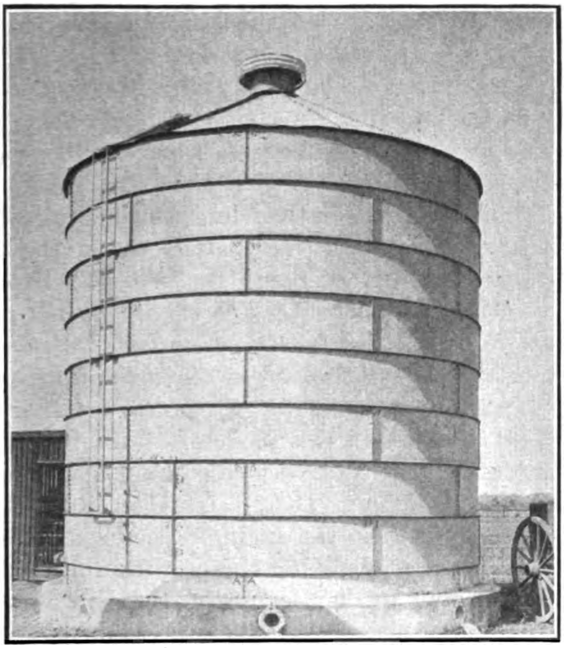

FIG. 16.—A modern galvanized-iron corncrib planned and erected by a progressive dairyman of Louisiana. Soft white dent corn has been kept in this crib in perfect condition for over a year. Weevils breed in such cribs as fast as in any, but are easily killed by fumigation with carbon disulphid. (Photograph by Jones.)

HEAT.

The average farmer is not equipped to use heat in controlling the Angoumois grain moth. Millers and grain dealers who have dryers can heat wheat to 120° F. *If grain is heated to a temperature of 120° F., all insects in it will be killed.* Heating to 120° F. will not injure its germinating power.

PARASITES.

Parasites[7] and a mite[8] often come to the farmers' aid and kill large numbers of the moth. Ordinarily, however, they do not become of service until the moth has caused much damage. It is not practical at present to depend upon parasites to reduce losses in field or storage.

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[7] *Pteromalus gelechiae* Webster.

[8] *Pediculoides ventricosus* Newport.

COMMUNITY EFFORT IN INSECT SANITATION.

The Angoumois grain moth has never been fought vigorously by farmers. Certain few men protect their crops and reap a saving. Many farmers wake up too late and find their crops already badly affected. Lack of labor and thrashing machines force some farmers to do the best they can. *But all farmers can support a campaign in their own communities to kill out the Angoumois grain moth.* Experiments have proved that the moth in the region of winter wheat can not live through the winter in the grain sown in the fall. Hence farmers can center their attack upon the pest in the cribs and granaries. Farther South the pest may live through the winter in grain left in the field. *The county agents representing both State and Federal departments of agriculture should interest farmers in their counties in campaigns along the lines of insect sanitation. No pest can be more effectively controlled than the Angoumois grain moth.* Success in this mode of attack in the northern range of the habitat of the pest depends upon the thoroughness with which farmers combine to treat infested grain in storage, and in cleaning out their cribs in the spring. In the more southern States success depends upon removing the crop thoroughly from the field as well as attending to disinfection in the crib and cleanliness of the crib after the crop has been removed from it. Dr. L. O. Howard first recommended control of the Angoumois grain moth through community effort over 25 years ago.

If county agents in sections where the moth is injurious can unite farmers in a campaign of control they will save the farmers of their counties grain worth many times the salaries paid them. Intelligent insect sanitation pays handsome returns.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1156

ANGOUMOIS GRAIN MOTH

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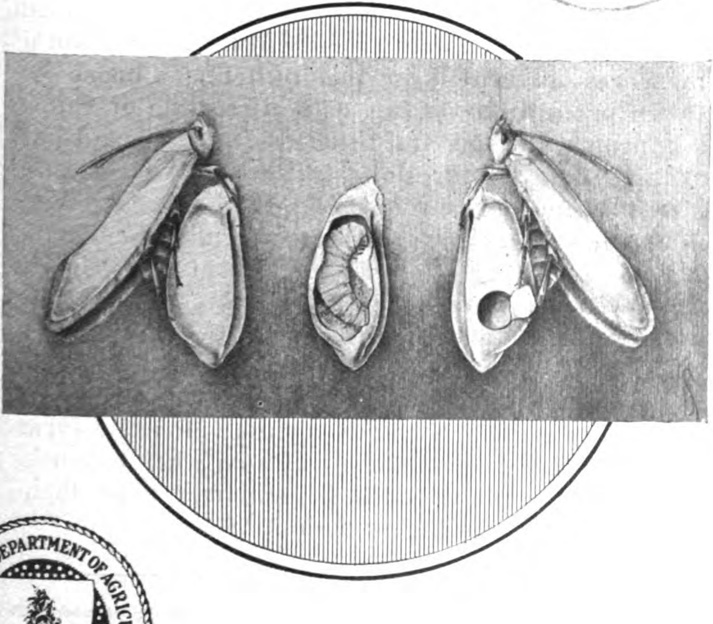

THE ANGOUMOIS grain moth, primarily a pest of wheat and corn in this country, attacks all cereal grains. It is particularly injurious throughout the Southern States. It does little harm north of central New Jersey except to cereals in storage.

It is second to the rice or "black" weevil in its capacity to damage grain. Often entire crops of corn and wheat are ruined. Millers are known to have refused to buy badly affected crops, as flour made from damaged wheat is not fit to eat. Wheat loses through moth attack about 52 per cent in weight. Corn, being larger, loses from 12 to 24 per cent in weight when kernels are attacked by a single insect only. As many as three or four moths, however, may develop in one corn kernel. The feeding of a single insect will completely ruin so small a grain as milo or sorghum.

Farmers suffer losses unnecessarily, for losses can be prevented by watchfulness and by application of measures advocated in this bulletin. Choose between prompt harvesting, early threshing or shucking, proper storage, and little loss, and delayed harvesting, delayed threshing in case of wheat, careless or improper storage, and large losses. Well-informed farmers are storing corn and wheat without loss by giving attention to cultural methods and treatment in storage by fumigation. Where one succeeds, all can.

All farmers can support campaigns to kill out the Angoumois grain moth. No pest can be controlled more effectively. If county agents will unite farmers to fight this pest they will save their counties grain worth many times the salaries paid them. Success awaits intelligent action.

Washington, D. C.

Issued September, 1920
Revised July, 1929

ANGOUMOIS GRAIN MOTH[1]

By E. A. Back, *Principal Entomologist in Charge, Division of Stored-Product Insects, Bureau of Entomology*

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ESTABLISHMENT AND SPREAD IN AMERICA

THE ANGOUMOIS GRAIN MOTH is a European pest that has become destructive to corn, wheat, and other grains in this country as a result of international commerce. It is called the Angoumois grain moth because as early as 1736 it had been a pest in the Angoumois Province of France, which included a region near the west coast north of Bordeaux. It is known also in America by the popular name of "fly weevil."

In the early days of American history there were no quarantine regulations to protect our agriculture from foreign pests. The Angoumois grain moth is one of those pests that are easily carried in grain from place to place. It was brought many times to this country in seed introduced from Europe by the earlier settlers of the various colonies along the Atlantic seaboard. Since it is a pest that is easily killed out by very cold winters, it is natural that its establishment in this country occurred in one of the Southern States. The first report of the occurrence of the Angoumois grain moth in this country was in 1728 in North Carolina, where it was causing damage to wheat. It was first reported in Maryland about 1769. Between 1728 and 1775 it had spread northward into Virginia, Maryland, lower Delaware, and probably southern New Jersey. In 1852 Harris wrote that wheat in Kentucky and in the southern parts of Ohio and Indiana was already affected. Though exact records of spread are not available, it is enough to know that from the original North Carolina-Virginia infestation the Angoumois grain moth has spread, chiefly through the shipment of seeds, southward through all the Southern States and northward. The farther south it has spread the more destructive it has become, because it can multiply unhampered by long, cold winters. On the other hand, its spread northward has been limited by increasingly cold winter weather.

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[1] *Sitotroga cerealella* Oliv.

While the moth causes much injury to the wheat crops in the southern parts of the North Central States and New Jersey, Delaware, southeastern Pennsylvania, Maryland, Virginia, and southward, crops grown still farther north are increasingly immune to attack in the field. After one passes the fortieth degree of north latitude injury from the Angoumois grain moth decreases rapidly. Because of the ease with which it can be carried in seeds the Angoumois grain moth is now and then reported from all States, even those possessing a climate far too cold to permit it to become a general pest.

DESCRIPTION

The Angoumois grain moth passes through the usual insect stages—the parent insect or moth, the egg, the larva, and the pupa.

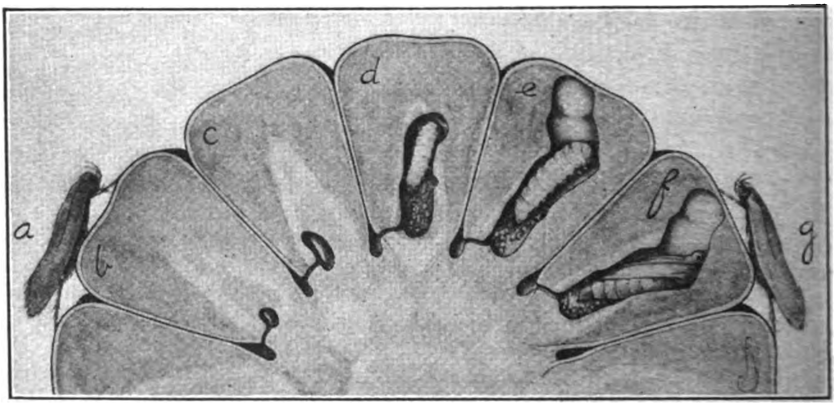

FIGURE 1.—Life cycle of the Angoumois grain moth in corn. The adult moth is shown at *a* and *g*. The larva is shown in different stages of its growth at *b*, *c*, *d*, and *e*. Notice that it begins feeding at the soft germ end of the seed and as it becomes larger eats out into the harder part of the corn. The larva transforms to the pupa as shown at *f*. From the pupa develops the adult moth *g* of the second generation

The moth is shown in Figures 1, 8, 11, and on the title page. It varies somewhat in color from buff to grayish or yellowish brown. In size it varies with the size of the grain in which it matures, but is never more than 0.6 to 0.7 of an inch from tip to tip of wings when these are spread as shown in Figure 8. The average wing spread of the moth is about one-half inch. Whenever moths of this size, closely resembling ordinary clothes moths, are seen flying about grain it is reasonably certain that the grain is infested with the Angoumois grain moth. The eggs laid by the moth are about one-fortieth of an inch long and are too small to be seen without the aid of a magnifying glass. They are laid on or near the grain. They are white when first deposited, but later turn a reddish color before the larva or grub hatches. An egg is shown in Figure 8, *b*. The larva is shown in Figures 1 and 8, and on the title page. When just hatched, the larva is tiny, being no thicker than a hair. After feeding in the grain it becomes full grown and is then about one-fifth of an inch long, white, with a yellowish-brown head. The pupa or chrysalis is reddish brown and is shown in Figures 1, 5, and 8.

INJURY

Injury to grains by the Angoumois grain moth is always done by the larvae. Injury is more difficult to detect in the early stages of infestation because the grub or larva bores its way into the seed when it is so small that the hole by which it enters can not be found without a close search with a magnifying glass. Usually after it has eaten its way into the seed, the larva turns about and spins a silken web over the opening by which it entered, thus making it even more difficult to locate the entrance hole. Once within the seed, the grub eats out the interior where it feeds unseen and often unsuspected by the owner of the grain. Usually the first indication the average grower has that his grain is infested is the simultaneous appearance of moths and the round holes (figs. 2, 5, 7, 8, and 9) that appear in the individual kernels, or sometimes by the heating of the grain in the bin. Then he finds upon cutting open the seeds in which the holes have appeared that they have been hollowed out by the larva (figs. 1, 4, 5, and 8) and that his grain has not only lost heavily in weight but that it contains much excrement and webbing left behind by the insect. The larva has jaws called mandibles, and it uses them almost continuously, first to gnaw its way into the seed and then to eat out the contents of the seeds to secure nourishment for its growth and to make the circular opening through which the moth itself emerges from the seed. The circular opening is not cut until the larva has become full grown. It then eats out a channel to the outside of the seed, leaving the merest film of the seed coat intact. The moth is strong enough to push off this "cap" when it leaves the seed. The opening is often called the emergence hole.

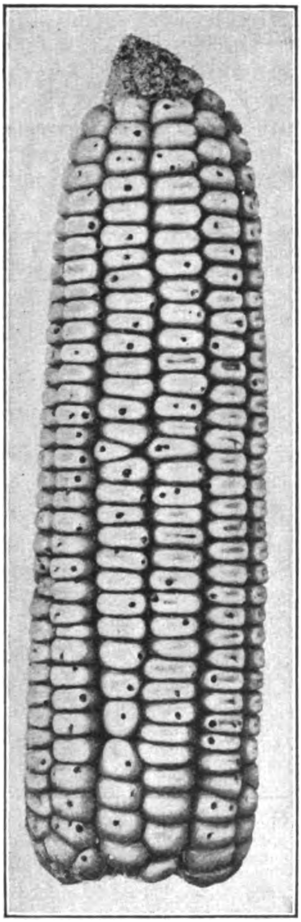

FIGURE 2.—An ear of corn showing the emergence holes of the Angoumois grain moth. When these holes begin to appear in your corn and small clothes-mothlike millers are found flying when the corn is disturbed, you may be certain that the Angoumois grain moth is already damaging your corn

FACTS REGARDING LIFE HISTORY

Under ordinary climatic conditions in those parts of the United States where the Angoumois grain moth is a pest, temperature seems the most important controlling factor in development. All the insects are killed if the infested grain is subjected to 120° F. for several hours. Exposure to 1° for 24 hours has prevented eggs from hatching. Ordinary winter storage below 60° will hold the moth in a quiescent or dormant state, provided the grain is not so badly infested that it is heating. Development goes on slowly between 60° and 70° and very rapidly between 70° and 95°. This explains how the Angoumois grain moth can breed generation after generation in warehouses or rooms kept at a moderately high temperature in a cold climate where the outdoor temperatures are too low for the moth.

During the summer and early fall the moths mate as soon as they crawl from the seeds in which they have developed. The female may start laying her eggs in less than 24 hours after emergence. Recent studies indicate that the moths are more prolific than was once believed.[2] Moths may lay as many as 300 eggs (283 eggs is the largest number actually laid by any one female under observation) although 150 is probably a fair average. The eggs are deposited singly or in batches on or near the grain. One female that began laying in late August deposited 204 eggs, as follows: 110, 33, 24, 16, 11, and 10 eggs, respectively, on the first, second, third, fourth, fifth, and sixth days. Another female, which emerged early in October, deposited 263 eggs during the 20 days after emergence. Naturally there exists considerable variation in the egg-laying capacity. Usually mated adults live about two weeks, but they may live as long as 38 days. As the males seem to emerge more quickly than the females, and as the sexes are about equally divided, the opportunity for mating and the production of fertile eggs is excellent. Though female moths may develop and lay eggs when they have nothing upon which to feed, access to water in the form of dew on growing wheat and corn appears to increase their egg-laying capacity.

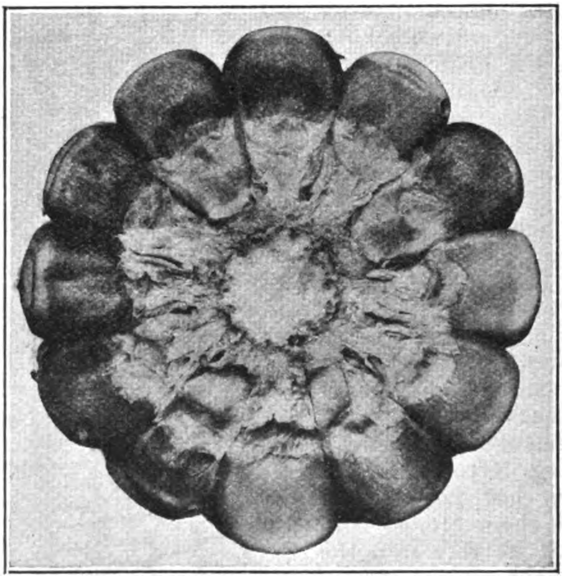

FIGURE 3.—An ear of corn badly damaged by the Angoumois grain moth, broken in two to show how perfect the kernels may appear when viewed from the side

During summer weather the eggs hatch when from 4 to 10 days old. Eggs may not hatch in colder weather for three or four weeks. In new-crop wheat the insects may require only 28 days from the hatching of the egg to the emergence of the moth from the kernel. This makes possible a minimum life cycle of a little less than five weeks.

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[2] SIMMONS, P., and ELLINGTON, G. W. BIOLOGY OF THE ANGOUMOIS GRAIN MOTH. PROGRESS REPORT. Jour. Econ. Ent., Vol. 17, pp. 41–45, 1924.

But there may be a variation as wide as four weeks in the time it requires specimens of the same brood to mature even in warm weather. Individuals hatching late in the season overwinter as larvae in the seeds. During the cold winter months the larvae lie dormant for four or five months, hence the life cycle may be fully six months long when a winter intervenes between the laying of the eggs and the emergence of the adults.

In the southern wheat belt of New Jersey there may be five generations of moths in a year under prevailing cultural conditions when wheat is left in the field until late in the season. The farther south one goes the greater is the number of generations, and in heated warehouses or rooms there may be as many as 10 or 12 generations per year.

ALL CEREAL GRAINS AFFECTED

The Angoumois grain moth has been bred from wheat, barley, oats, buckwheat, corn, sorghum, milo, rice, beans, chickpeas, and cowpeas. It is a general feeder upon seeds of the cereal type. It causes greatest loss to wheat and corn in this country, though instances of serious attack are recorded frequently upon other grains. Beans, chickpeas, and cowpeas usually are not attacked, though if held in storage for considerable periods the Angoumois grain moth has been known to cause much damage, particularly in seeds already slightly injured by handling or by bean-weevil attack. Rice handled under commercial conditions is very seldom affected.

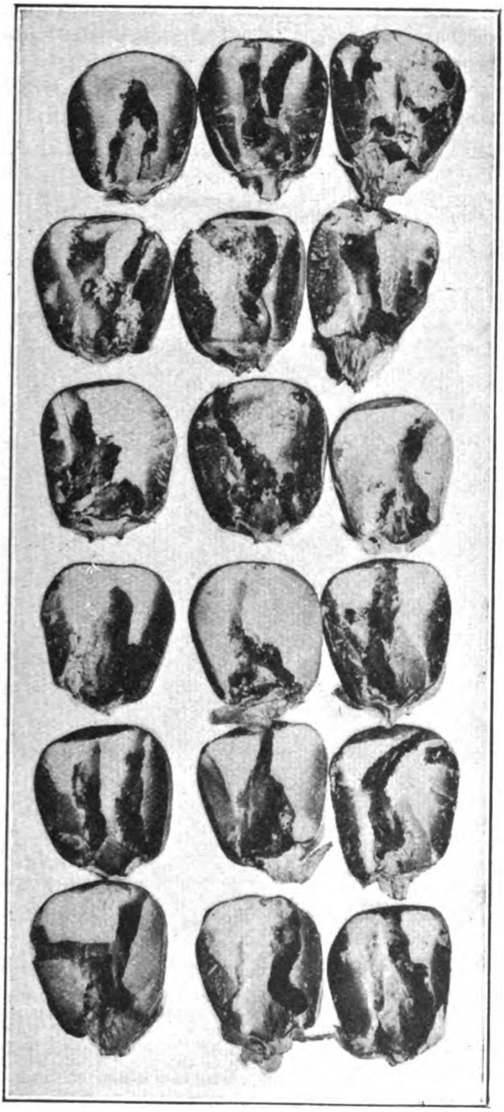

FIGURE 4.—Kernels of corn cut in two to show the damage caused by the larva or worm of the Angoumois grain moth. The worm usually enters the seed at the base, destroys the germ, and then tunnels toward the tip of the kernel. Affected kernels nearly always are ruined for planting purposes

LOSSES

It is difficult to estimate the amount of loss caused grain growers, dealers, and millers by the Angoumois grain moth. Throughout the extreme South it is rated as a pest second only to the rice or "black" weevil.[8]

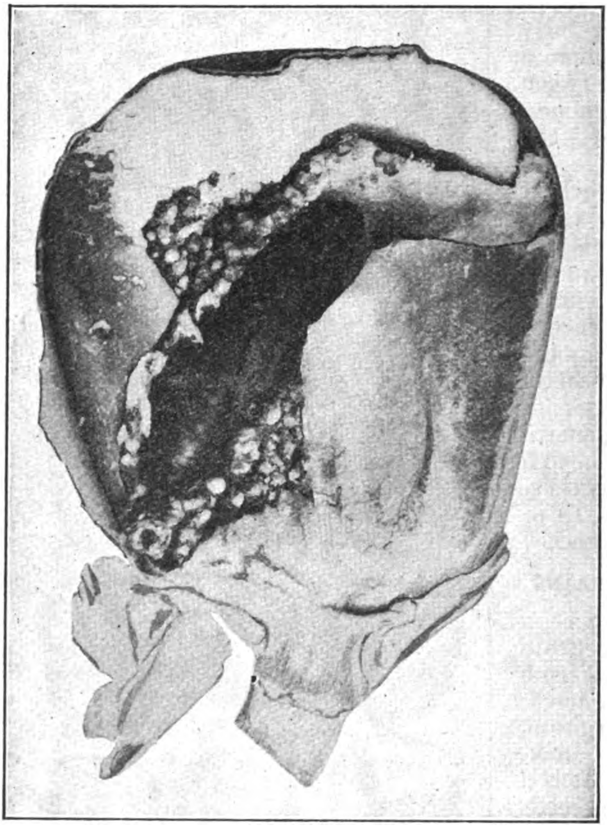

FIGURE 5.—Cross section of one of the kernels of corn in Figure 3, enlarged to show the cavity made by the larva of the Angoumois grain moth, the silken chamber formed by the larva, before transforming to the pupa. The large brown or blackish appearing object is the pupa from which the moth will emerge and crawl along the silken channel in escaping from the seed

Throughout the wheat belt of southeastern Pennsylvania, New Jersey, Delaware, and Virginia, it is the worst pest of ripening wheat and wheat in storage. Many crops have suffered a loss of 10 to 60 per cent. Millers have not infrequently refused to purchase badly damaged grains because they contained so many dead insects and insect excrement. Flour made of badly infested seeds is not palatable. The actual weighing of 1,000 kernels of sound wheat and a like number of infested kernels showed a loss by weight of 56.2 per cent as a result of the development of a single moth in each of the infested kernels. (Fig. 9.)

Corn does not lose so great a percentage of its weight. The weights of an equal number of infested and perfect kernels representing seven varieties of soft, dent, and flint corn showed that where but one moth had developed in each infested kernel the infestation had caused a loss in weight amounting to 13.1, 13.2, 15.5, 17.3, 19.7, 23.5, and 24 per cent, respectively. The loss in weight varies with the ratio between the size of the kernel and the amount eaten by the individual insect in reaching its maturity.

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[8] *Calandra oryza* L.

MATURING GRAIN AND STORED GRAIN SUBJECT TO ATTACK

The Angoumois grain moth feeds both in dried grain in storage and in grains maturing in the field. In storage the pest breeds generation after generation as long as the food supply lasts. This may be several years in what are commonly believed to be "air-tight" containers. In agricultural districts, especially where the pest is breeding in storage in open bins or mows, the moth is driven by instinct to leave the warehouse, barn, or crib in varying numbers and fly to the near-by fields in search of maturing grains in which to lay eggs for the first summer generation in the field. Of course, many remain behind in the crib to multiply continuously throughout the year.

INFESTATION OF CORN

Corn has an advantage over the smaller grains in that most of the kernels are covered during growth by the husk covering. It has already been pointed out that destruction by the Angoumois grain moth takes place in the larval stage. The parent which flies from grain in storage to the field to start the first generation in maturing grain can not eat into the shuck covering. Hence corn protected by a well-developed, uninjured shuck covering is never affected. But where the shuck is either loosely developed at the tip or damaged by smut, corn ear worm,[4] or other insects, the moth can easily reach the kernels and lay her eggs upon them, thus starting an infestation.

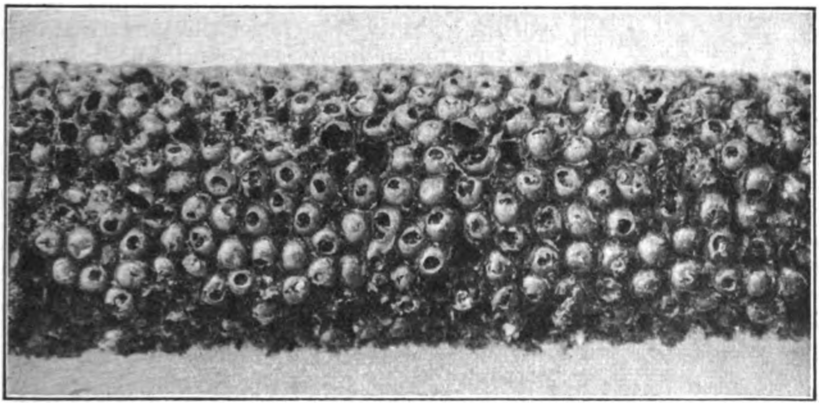

FIGURE 6.—A spike of sorghum with each seed showing the emergence hole of the Angoumois grain moth. The moth completely ruins so small a seed as this

These relatively few cases of infestation in the field serve as centers of infestation from which following generations of moths maturing in standing corn or corn shocked in the field, or corn that has been placed in the crib, will spread in large numbers and bring about a general infestation of the entire lot of corn in storage. There is practically no infestation of corn in the field except in the more southern States. As far north as Maryland instances of field infestation are very rare, and there is little danger of infestation where corn is stored in ordinary slatted cribs until the coming of warm weather of the following summer. But in the Gulf Coast States, especially when the corn is growing on poor land, where shuck development is poorest, the infestation of maturing ears may be very general and result in heavy losses in storage.

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[4] *Heliothis obsoleta* Fab.

Figures 1 to 5 and 10 illustrate the manner in which corn is injured. The moth lays her eggs usually between the kernels on the cob. On shelled corn the eggs may be laid anywhere. The newly hatched larva usually crawls to the germ end of the seed, bores in through the seed coat, which is there more tender, and thus finds itself in the softest part of the kernel. From the illustrations it will be seen that the larva usually eats out and destroys the embryo or germ, and then bores its way outward into the harder part of the seed. (Figs. 1 and 4.) More often the emergence hole is found on the outer portion of the kernel, though this is not always so. Ordinarily development occurs entirely within a single kernel, yet the larva may begin its feeding in one kernel and finish it in the adjoining one. In some varieties of corn many larvae form their emergence holes at the base of the kernel, so that the moth in attempting to escape from the kernel finds itself wedged in by the surrounding kernels and forced to starve, since only the larva of the moth can feed on grain. Although many moths in an ear may lose their lives in this way, yet enough emerge normally to cause heavy infestations.

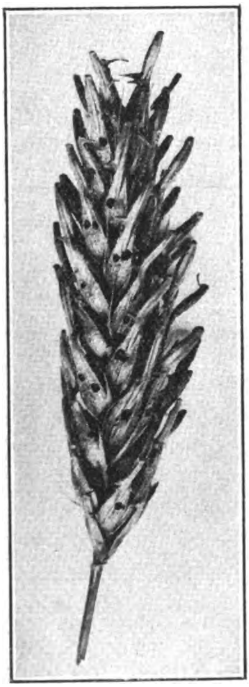
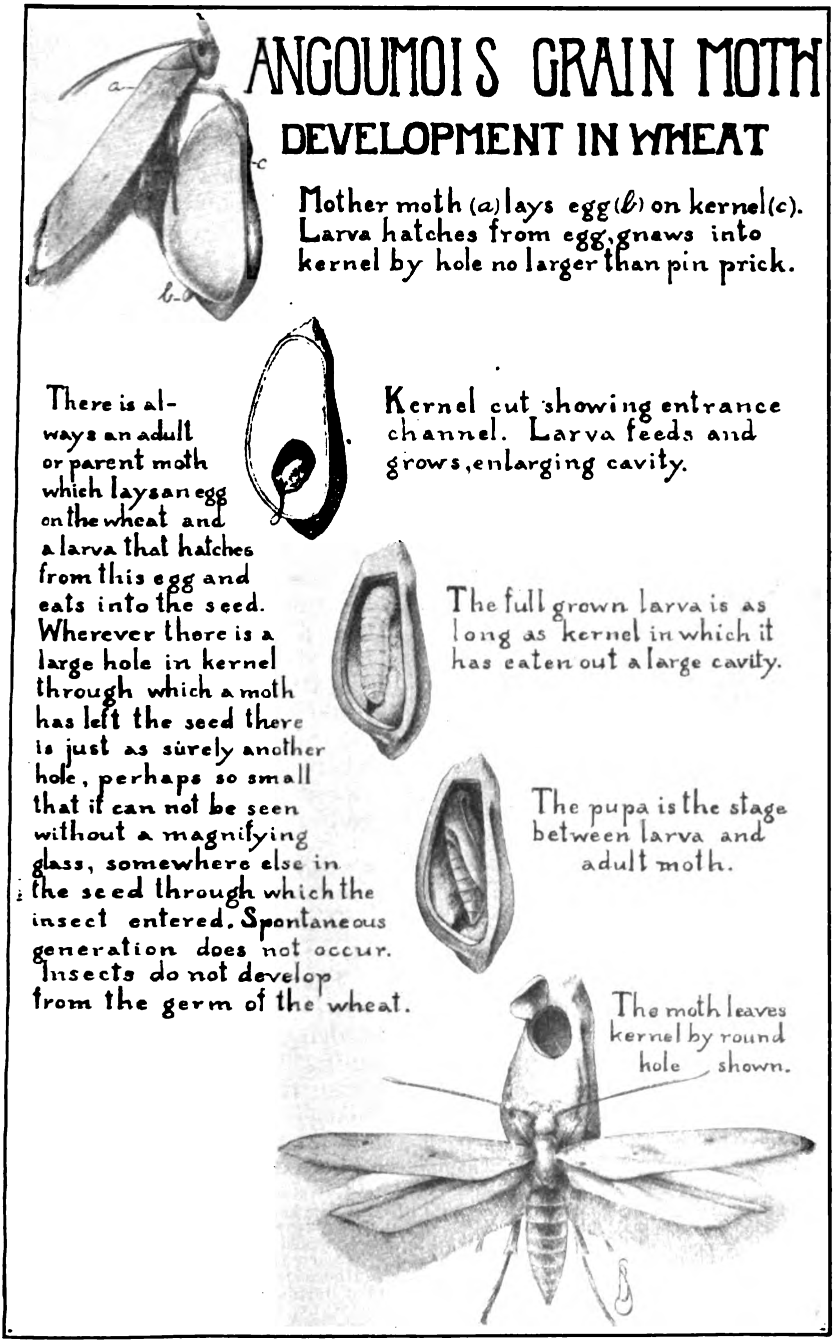


FIGURE 7.—A head of beardless barley showing the emergence holes of the Angoumois grain moth. Remember that unthreshed wheat, rye, oats, or barley are not at all protected from the moth

While the young larva can not eat through corn shucks to reach the kernels, those hatching from eggs laid through breaks in the shuck covering may be so numerous, particularly in storage, that they spread to and enter nearly all the kernels on an ear, even those kernels well covered by the shuck. Although the newly hatched larva can not eat through the shuck to the kernel, the mature larva, which is much stronger, may bore its way out from the kernel through the shuck covering to the exterior. Instances have been found where the larva of the Angoumois grain moth has eaten through eight and nine thicknesses of shuck covering, though ordinarily escape is not effected where there are this number of thicknesses. Infestation of kernels at the tip of an ear may take place if the silk has been eaten out, thus leaving a channel down which either the moth or the newly hatched larva can crawl. While the infestations that occur through eaten-out silk channels and through breaks in the shuck covering are not in themselves usually of importance from the standpoint of grain actually destroyed, they are of immense importance as "leaven"



ANGOUMOIS GRAIN MOTH

DEVELOPMENT IN WHEAT

Mother moth (a) lays egg (b) on kernel (c). Larva hatches from egg, gnaws into kernel by hole no larger than pin prick.

Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.

There is always an adult or parent moth which lays an egg on the wheat and a larva that hatches from this egg and eats into the seed. Wherever there is a large hole in kernel through which a moth has left the seed there is just as surely another hole, perhaps so small that it can not be seen without a magnifying glass, somewhere else in the seed through which the insect entered. Spontaneous generation does not occur. Insects do not develop from the germ of the wheat.

The full grown larva is as long as kernel in which it has eaten out a large cavity.

The pupa is the stage between larva and adult moth.

The moth leaves kernel by round hole shown.

Figure 8.—Development of Angoumois grain moth on wheat. Life cycle

for the subsequent infestation of entire crops held carelessly in storage.[5]

FIELD INFESTATION OF WHEAT

It has been stated already that the adult of the first generation of the Angoumois grain moth instinctively flies from the crib or storage house to the near-by fields of grain as the crop is approaching maturity. It also has been stated that the moth can not infest the corn if the shuck covering is well developed and uninjured. The planting of varieties of corn developing a long, tight shuck, as recommended by the department,[6] will greatly lessen moth injury in the field. But this advantage which corn has is not shared by wheat, barley, and similar small grains. The female moth upon flying from bin to field may lay from 20 to 30 eggs upon the head of wheat chosen for attack. The larvae hatching from these eggs scatter over the head, only one entering each kernel. The thin membranes covering the kernel are no hindrance to the entrance of the larvae. This starting of infestation in the field may take place, as King[7] has proved beyond doubt, even while wheat is "in the milk." Infestations of growing wheat are most heavy nearest places where infested wheat has been stored throughout the winter and spring.

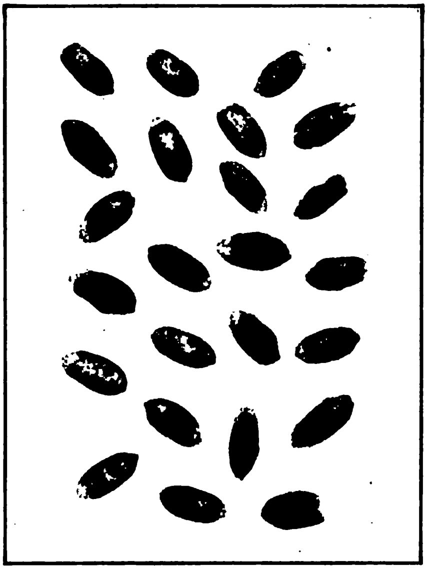


FIGURE 9.—Kernels of wheat showing the small round emergence holes that prove that an Angoumois grain moth has developed in the seed, thus reducing its weight somewhat over 50 per cent

EARLY FIELD INFESTATIONS AND DELAYED HARVESTING INCREASE OPPORTUNITY FOR DAMAGE

There is a direct relationship overlooked by many wheat growers between early field infestation, delayed harvesting, and damage caused by the Angoumois grain moth. In southern New Jersey, Maryland, and southeastern Pennsylvania the first moths appear in the wheat fields about the time the wheat is "in the milk." In other words, the moth may begin to lay eggs in the wheat heads at any time after the kernels are well set.[8] As each moth may live from 10 to 38 days, during which she flies about the field laying eggs in batches of 1 to 20 or more until she has laid about 150 eggs, it will be understood that a field of grain may have many heads infested by the early summer flight of moths from near-by cribs or granaries. Ordinarily these first early summer infestations are very slight and cause no appreciable loss if the crop is handled correctly.

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[5] If the Angoumois grain moth were the only pest farmers had to contend with, it would be better to keep corn in storage with the shucks on, as good shuck cover is a great aid to conservation of corn against this pest. Unfortunately in sections where the moth is a serious pest of corn, the corn is also attacked by the rice or "black" weevil, against which shucks are of far less protection. If corn is shucked at harvest and fumigated at once, so practical experience on the southern farms is proving, losses due to any insect are greatly reduced or entirely prevented during the time of storage.

[6] For further discussion of long tight shuck, see KYLE, C. H. HOW TO REDUCE WEEVIL WASTE IN SOUTHERN CORN, U. S. Dept. Agr. Farmers' Bul. 915, 8 p., illus. 1918.

[7] KING, J. L. THE ANGOUMOIS GRAIN MOTH. Pa. Dept. Agr., Bur. Plant Industry Circular No. 1, 14 p., 2 figs. 1920.

Field infestation at the time wheat is ready for harvest has been observed to amount to from 0.26 to 2.06 per cent of the kernels. This is equal to a population of 28,500 to 225,000 moths per acre.

SECOND AND THIRD GENERATIONS IN FIELD SPREAD LIKE WILDFIRE

The first generation of moths in the maturing heads of wheat, as just stated, usually is not a large one. But for each female moth of the first generation that reached the field in late May and June there may be 150 moths of the second generation maturing in middle July and August. Ordinarily the

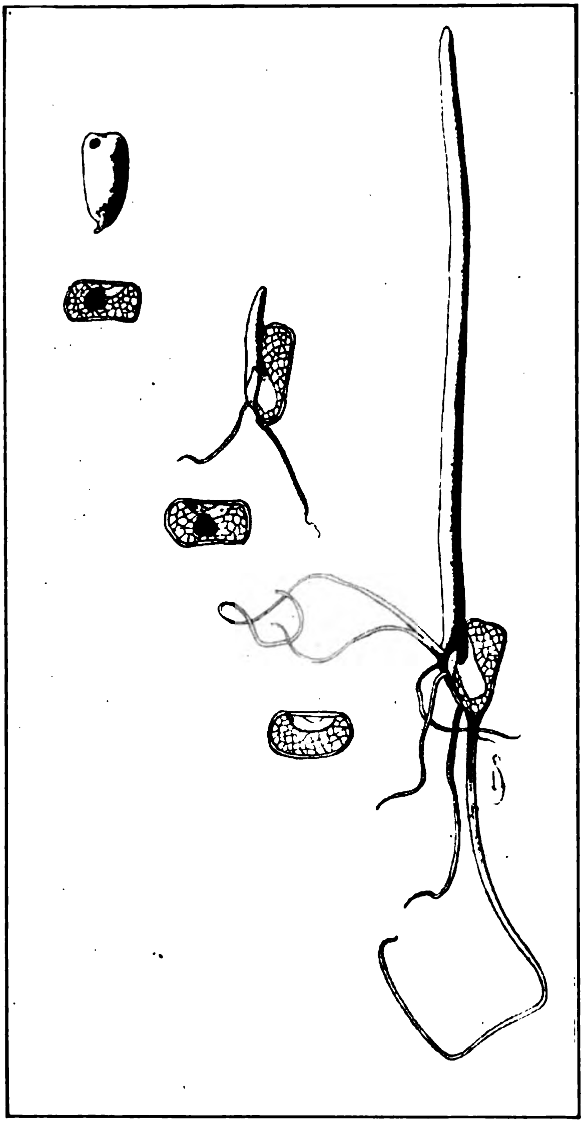

FIGURE 10.—Three kernels of corn, the lowest one free from attack and sprouting normally. The larva of the Angoumois grain moth has completely destroyed the germ of the upper kernel and it has failed to sprout. The germ of the middle kernel has been affected only slightly by the developing moth, yet notice how small its shoot is as compared with that of the normal seed; it will die or produce a sickly plant. Do not plant seed infested with the Angoumois grain moth

moths of the second generation begin to appear soon after the grain is ready to cut, though a few may mature before the grain is ripened. The moths for the third generation appear during late August and during September. Granting that the sexes are evenly divided, and each female will lay on an average 150 eggs, for each female moth flying to the field in May or June there are about 11,250 moths, or 5,625 female moths ready to start the third generation of infestation in late August and September, and these moths are capable of laying 843,750 eggs. As only one Angoumois grain moth usually develops in a single wheat kernel, for each infested kernel in May and June there may be in late August and September 843,750 infested kernels. And if the grain is stored unthreshed in the barn where the moths can easily reach the kernels, or is left unthreshed in the field during warm weather, infestation may increase to 63,281,250 kernels in October for each infested kernel in May or June, provided all eggs hatch, all larvae reach maturity, and all females lay an average of 150 eggs. If this infestation which occurs before threshing could be eliminated this severe and widespread damage now often caused by the moth would be a thing of the past.

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[8] SIMMONS, P., and ELLINGTON, G. W. DISPERSION OF THE ANGOUMOIS GRAIN MOTH TO WHEAT FIELDS. Jour. Agr. Research, Vol. 34, pp. 459–471. 1927.

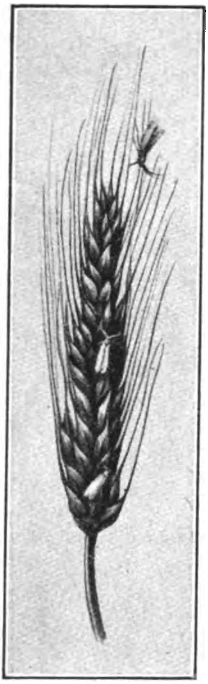

FIGURE 11.—A head of maturing wheat showing three adult Angoumois grain moths that have flown from the crib to the field of ripening grain and are seeking to lay eggs upon the head

PROMPT THRESHING MEANS SAVING

It is known that grain standing in the field uncut, grain stacked in the field, or mowed away unthreshed in barns, is not protected from so small an insect as the Angoumois grain moth. The moths are so small that they can crawl into unthreshed grain and lay their eggs. They prefer the more exposed outer heads but they can infest the inside heads. It is also known that the Angoumois grain moth while very small is too weak to force its way down into wheat or any grain when it is stored in bulk or large quantities. When stored in bins only the upper 1 or 2 inches of grain become infested. Since the moth is too weak to burrow down into a mass of wheat, it is also too weak to push the kernels aside and crawl to the top of the bin if it comes out of a kernel more than 2 or 3 inches below the surface of the grain.

TAKE ADVANTAGE OF THE INSECT'S WEAKNESS

Farmers can turn this weakness to their advantage. If wheat is cut as soon as ripe, threshed as soon as dry, and placed at once in storage in deep bins where only a relatively small surface of wheat is exposed, the Angoumois grain moth will not ordinarily cause trouble. The relatively small quantity of wheat that is infested by the time it is ripe and can be threshed is not great enough to cause heating in the bins as a result of moth infestation. The moths that develop in the kernels well below the top of the bin die without reproducing because they are too weak to extricate themselves. The same result is obtained when the wheat is placed in closely woven sacks that are well closed. The early harvesting and proper storing of wheat nips in the bud the first early infestations that occur in the field, without cost or material loss to the grower.

DELAYED THRESHING RUINS MANY CROPS

The greatest argument against early threshing of wheat is the difficulty of getting a threshing machine just when it is needed. Where a community depends upon a traveling threshing machine, farmers must wait their turn. A period of wet weather after cutting may prevent threshing, though it does not prevent the moth from multiplying. Wet weather can not be overcome, but farmers can combine more effectively in arranging for the prompt threshing of their wheat. The amount of wheat saved by early threshing during occasional bad "fly weevil" years will often pay many times over for the investment required to own a threshing machine. The farmer can choose between prompt harvesting, early threshing, proper storage, and little or no loss, and delayed harvesting, late threshing, and great loss. It will pay him to provide against loss.

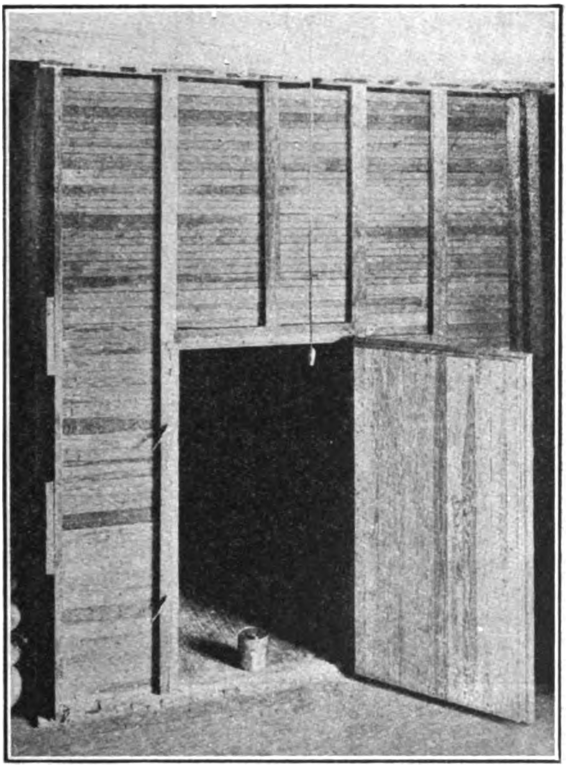

FIGURE 12.—Front view of a specially constructed fumigating room used for killing insects in corn, wheat, and other substances. It is made of double thicknesses of matched boards with building paper between. Such a room is valuable for fumigating sacked grain with carbon disulphide or other effective fumigant

REMEDIAL MEASURES

The most satisfactory method of controlling the Angoumois grain moth attacking almost any crop, but especially wheat, is, as just stated, prompt harvesting and storing under conditions unfavorable to the moth attack. (Figs. 12 to 16.) The great losses that are reported throughout wheat areas affected by the pest are the result of delayed harvesting, threshing, and storing. The storing of wheat unthreshed in barns or stacking it unthreshed in the field increases the loss. Prompt harvesting, threshing, and storing in deep, tight bins, or in tight sacks, is effective. Wheat should never be left spread in thin layers on barn floors except when too wet to store. Such a practice makes it easy for the moth to lay eggs on kernels.

DRYNESS

It is stated that where practicable to store grain under dry conditions, the amount of damage done by the Angoumois grain moth will be reduced greatly. If the moisture of the grain can be reduced to 13 per cent or below, infestation will make little or no headway.

FUMIGATION

If grain is found badly infested with the Angoumois grain moth, it should be fanned and screened. Such treatment will remove about half of the infested kernels of wheat, but will not remove infested kernels of corn. Remember fanning only removes adult moths, débris, and light kernels. To kill the moth in the remaining crop the seeds must be fumigated or heated. The best fumigants are hydrocyanic-acid gas, carbon disulphide, and the ethylene dichloride-carbon tetrachloride mixture. Hydrocyanic-acid gas is lighter than air, very deadly to man as well as insects, and is used in killing the moths in grain stored unthreshed. It is not recommended for the treatment of threshed grain in bulk unless the fumigation is effected through the addition of calcium cyanide to the stream of wheat as the grain enters the bin. This fumigation of bulk grain with calcium cyanide is conducted only at elevators where special equipment for the application is available. Farmers with ordinary bins should not attempt to use calcium cyanide until this method of control has been developed further, because of certain risks connected with its use.

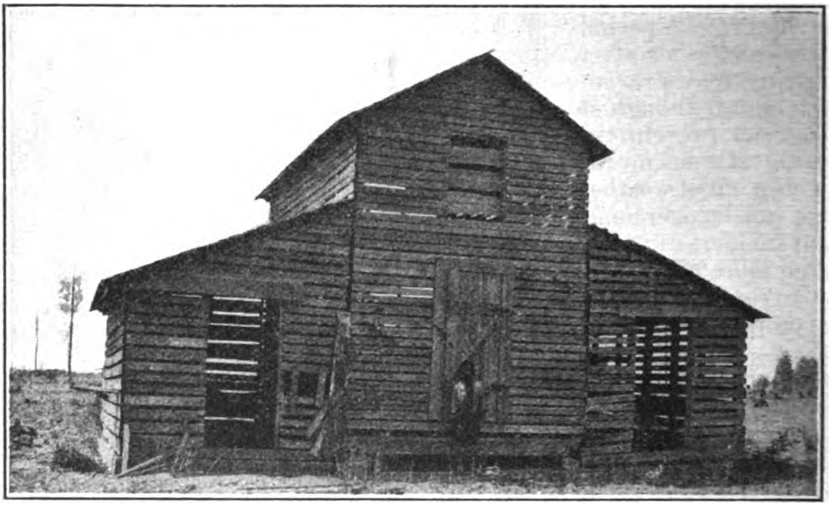

FIGURE 13.—A slatted corncrib. Such corncribs are no protection from insects to corn stored in them in the extreme South. Corn stored in slatted cribs from Maryland northward is safe from Angoumois grain moth attack at least until the summer following harvest, as the cold of winter is usually sufficient to prevent moths from surviving the winter in slatted cribs

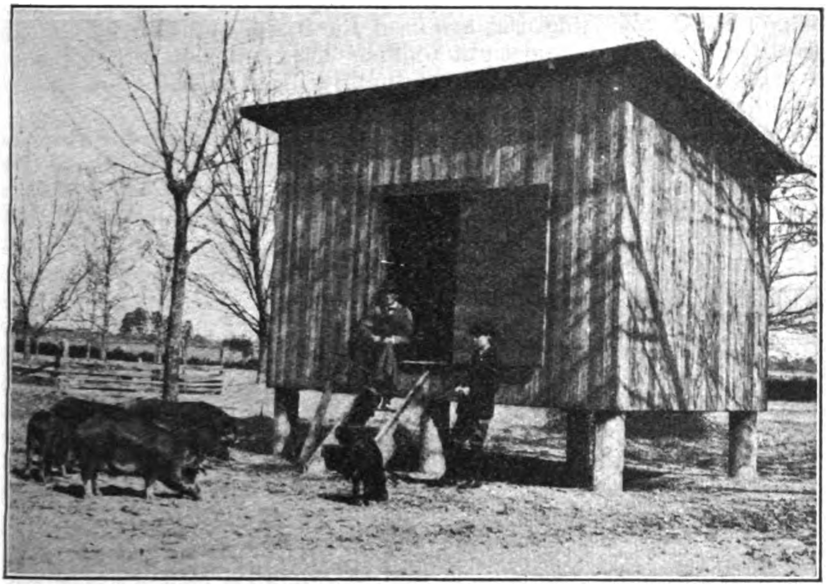

FIGURE 14.—Corncrib belonging to farmer in Georgia. This was originally a slatted crib, but the weevils were so destructive that he covered it with building paper and a layer of tongue-and-groove boarding, made his floor tight, and fumigated with carbon disulphide. He no longer fears weevils. Anyone can make his crib tight by following the advice of the county agent

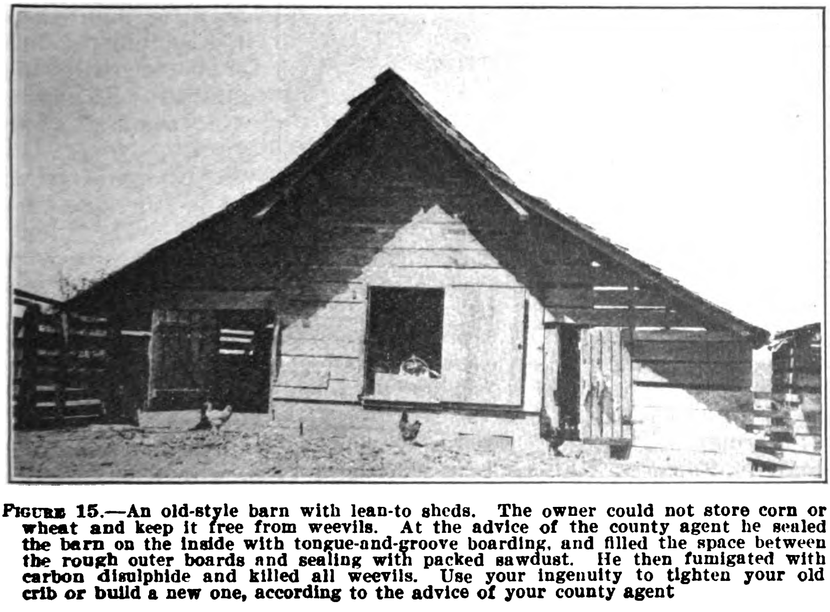

FIGURE 15.—An old-style barn with lean-to sheds. The owner could not store corn or wheat and keep it free from weevils. At the advice of the county agent he sealed the barn on the inside with tongue-and-groove boarding, and filled the space between the rough outer boards and sealing with packed sawdust. He then fumigated with carbon disulphide and killed all weevils. Use your ingenuity to tighten your old crib or build a new one, according to the advice of your county agent

Threshed grain in bulk should be fumigated with carbon disulphide or the ethylene dichloride-carbon tetrachloride mixture. These gases, which are heavier than air, are used for the destruction of moths in grain stored in bins and tight rooms. They will not injure the seed for planting if the seeds are thoroughly dried at the time they are fumigated.

At present carbon disulphide is a standard fumigant for farm use, and is safely and successfully used by thousands of farmers. Precautions, however, are necessary in its use. *Keep all lighted cigars, matches, lanterns, or fire in any form away from the bins or buildings during the fumigation, as the gas is explosive and inflammable in the presence of the smallest spark.* Fumigations are not very effective at temperatures lower than 60° F. Carbon disulphide should be used at the rate of from 4 to 10 pounds for each 1,000 cubic feet of bin space to be fumigated, according to the tightness of the bin. It pays to make the bin tight and save on the cost of the fumigant. Carbon disulphide may be poured directly upon the seeds, or better still upon gunny sacks spread over the top of the grain. Never pour the fumigant on the seeds at one spot only. The liquid will not injure the seeds for feeding or milling if used as directed, but if poured in one spot the seeds there may become so wet that their milling properties may be affected. The liquid quickly evaporates at temperatures over 60° F., forming a gas that sinks into the grain and kills the insects.

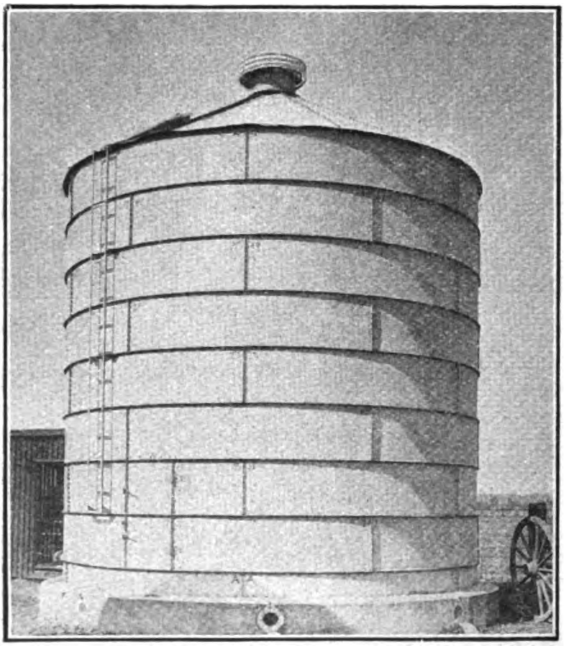

FIGURE 16.—A modern galvanized-iron corncrib planned and erected by a progressive dairyman of Louisiana. Soft white dent corn has been kept in this crib in perfect condition for over a year. Weevils breed in such cribs as fast as in any, but are easily killed by fumigation with carbon disulphide. (Photograph by Jones)

Information regarding the fumigating of grain is given more in detail in Farmers' Bulletins Nos. 799 and 1483, which may be had free by writing to the Department of Agriculture, Washington, D. C.

HEAT

The average farmer is not equipped to use heat in controlling th Angoumois grain moth. Millers and grain dealers who have dryer can heat wheat to 120° or 125° F. If grain is heated to this temperature for several hours all insects in it will be killed. Heating to from 120° to 125° will not injure its germinating power.

PARASITES

A parasite[9] and a mite[10] often come to the farmers' aid and kill large numbers of the moth. Ordinarily, however, they do not become of service until the moth has caused much damage. It is not practical at present to depend upon parasites to reduce losses in field or storage.

COMMUNITY EFFORT IN INSECT SANITATION

The Angoumois grain moth has never been fought vigorously by farmers. Certain few men protect their crops and reap a saving. Many farmers wake up too late and find their crops already badly affected. Lack of labor and threshing machines forces some farmers to do the best they can without them. But all farmers can support a campaign in their own communities to kill out the Angoumois grain moth. Experiments have proved that the moth in the region of winter wheat can not live through the winter in the grain sown in the fall. Hence farmers can center their attack upon the pest in the cribs and granaries. Farther south the pest may live through the winter in grain left in the field. The county agents representing both State and Federal departments of agriculture should interest farmers in their counties in campaigns along the lines of insect sanitation. No pest can be more effectively controlled than the Angoumois grain moth. Success in this mode of attack in the northern range of the habitat of the pest depends upon the thoroughness with which farmers combine to treat infested grain in storage, and in cleaning out their cribs in the spring. In the more southern States success depends upon removing the crop thoroughly from the field as well as attending to disinfection in the crib and cleanliness of the crib after the crop has been removed from it. L. O. Howard first recommended control of the Angoumois grain moth through community effort over 30 years ago.

If county agents in sections where the moth is injurious can unite farmers in a campaign of control they will save the farmers of their counties grain worth many times the salaries paid them. Intelligent insect sanitation pays handsome returns.

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[9] *Pteromalus gelechiae* Webster.

[10] *Pediculoides ventricosus* Newport.

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June 26, 1929

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WATERPROOFING AND MILDEWPROOFING OF COTTON DUCK

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FARMERS' BULLETIN 1157

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C. October, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 192

ONLY unbleached, unsized, closely woven duck should be used for farm purposes, and, unless the canvas is to be subjected to a proofing treatment, it is recommended that only mineral-dyed khaki be bought for out-of-door use.

It is more economical to buy a good grade of duck, even at a decidedly higher first cost, than a cheap duck of light weight and poor construction.

Mildew is the chief cause for the deterioration of cotton duck. Untreated duck always mildews in warm weather if stored wet or even slightly damp. To prevent mildewing, the canvas should be thoroughly dried in the open air before it is folded and stored.

Any treatment which decreases the absorption of water by canvas increases its mildew resistance. In humid climates or seasons, or under conditions of service where the canvas remains wet or moist for several days at a time, a treatment which will decrease water absorption and, in consequence, susceptibility to mildew, should be applied.

Satisfactory results for increasing the serviceability of cotton duck have been obtained with the formulas given in this bulletin. One coat applied to one side of the canvas usually is sufficient.

WATERPROOFING AND MILDEWPROOFING OF COTTON DUCK.

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USE OF COTTON DUCK.

COTTON DUCK, otherwise known as canvas, is used extensively for the protection of machinery, sacked grain, shocks, stacks and ricks, for wagon and truck covers, for awnings and temporary shelters, for horse covers, and for catching grain which falls to the ground during thrashing. Undoubtedly it would be used to a greater extent if it fulfilled more effectively these various purposes and if it retained its serviceability for a longer period than it ordinarily does.

This bulletin tells how to select and care for duck or canvas on the farm and describes simple methods for prolonging its period of serviceability by the application of waterproofing and mildewproofing treatments.

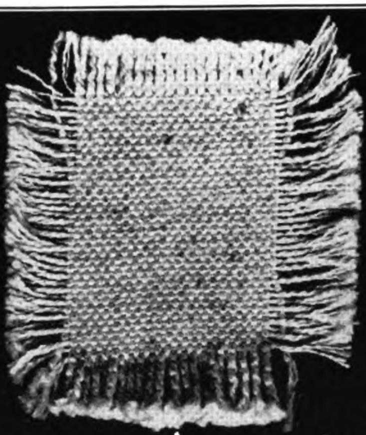
CLASSES OF COTTON DUCK.

Two general classes of cotton duck are known to the cotton-goods trade. They are "numbered duck" and "ounce duck."

"Numbered ducks" are made of multiple-ply yarns in both the warp and filling directions. The numbers run down, and the weights up, from 12 to 0 (or more ciphers), with a difference in weight between the consecutive numbers of 1 ounce per linear yard 22 inches wide. The canvas can be bought in widths of from 22 to 144 inches. Number 12 duck, which is the lightest of this class, weighs 7 ounces per linear yard 22 inches wide, or about 11.5 ounces per square yard. Number 00 duck, the heaviest commonly used, weighs 20 ounces per linear yard 22 inches wide, or about 32.7 ounces per square yard.

"Ounce ducks" are usually from 28½ to 30 inches wide and weigh from 6 to 15 ounces per linear yard. There are three grades or qualities of ounce ducks:

(1) *United States standard Army duck.*—This is the best grade of light and medium-weight duck on the market. It is made of multiple-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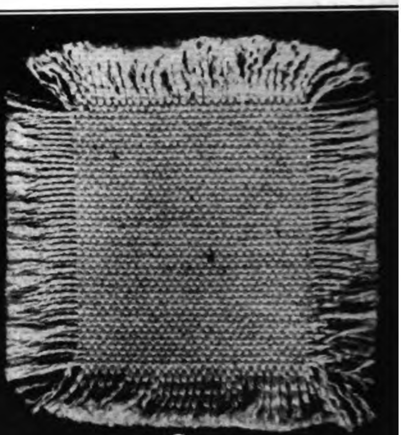
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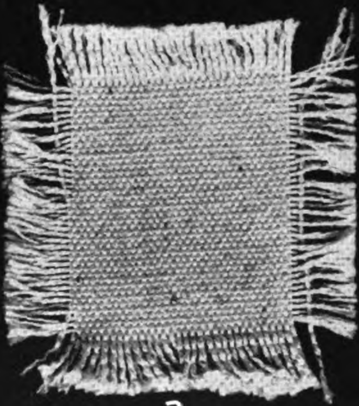
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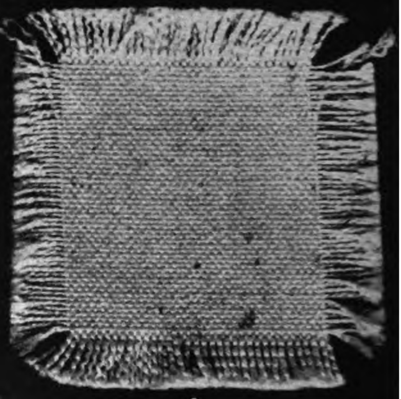
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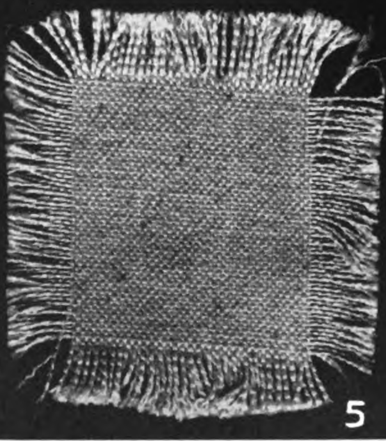
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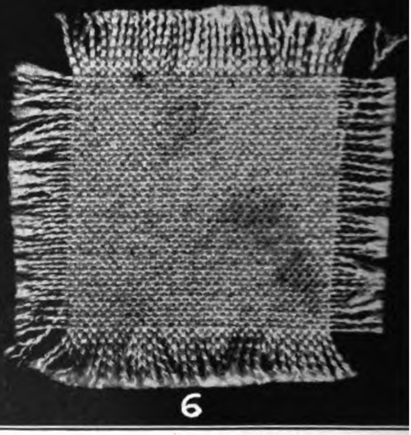
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FIG. 1.—No. 8 duck.
FIG. 2.—15-ounce U. S. standard Army duck.
FIG. 3.—No. 10 duck.
FIG. 4.—12-ounce standard Army duck.
FIG. 5.—No. 12 duck.
FIG. 6.—10-ounce U. S. standard Army duck

ply yarns both in the warp and filling directions, and is not bleached, loaded, or sized (figs. 2, 4, 6, and 13).

(2) *Double-filled duck.*—The warp consists of single-ply yarns and the filling of multiple-ply yarns (figs. 7, 9, 11, and 14).

(3) *Single-filled duck.*—Both the warp and filling are made of single-ply yarns. This is the cheapest and poorest grade of duck on the market (figs. 8, 10, and 15).

In both the double-filled and single-filled ducks the filling yarns are much heavier than the warp yarns. In order to make a canvas of more uniform appearance, therefore, the warp yarns are usually woven in pairs, resulting in a loosely woven duck which has little water resistance and can not be as thoroughly waterproofed as the multiple-ply ducks.

Double-filled and single-filled ducks are the kinds most commonly used for awnings. As a rule they have been bleached and are also usually heavily sized to give weight to the material. They are not recommended for out-of-door service.

SELECTION OF COTTON DUCK FOR FARM USE.

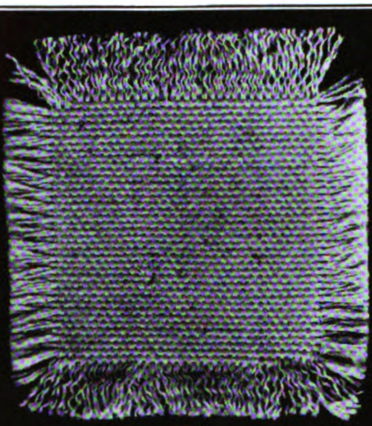
For farm purposes only unbleached, unsized, closely woven duck should be used. It should not be too stiff, however, nor so closely woven that it has no flexibility when wet and cold, in which case it has a tendency to crack when creased or folded. Furthermore, stiff canvas is very difficult to handle, and, when used as a cover, does not shape itself properly to objects, as a result of which it does not give them adequate protection. For horse covers a moderately stiff canvas is preferable, as it does not lie close to the body of the animal and does not cause sweating as readily as the more flexible material.

Large wagon covers or paulins.—These should be made of No. 8 duck, which weighs about 18 ounces per square yard, or of 15-ounce United States standard Army duck, weighing about 18.9 ounces per square yard (figs. 1 and 2).

Small wagon and machine covers or tents.—Either No. 10 or 12-ounce United States standard Army duck is suitable for this purpose, as both have sufficient body without being too stiff when wet. No. 10 duck weighs about 14.7 ounces and 12-ounce United States standard Army duck about 15.2 ounces per square yard (figs. 3 and 4).

Shock and other small covers.—No. 12 duck, weighing about 11.5 ounces per square yard, or 10-ounce United States standard Army duck, weighing 12.6 ounces per square yard, is satisfactory for this purpose (figs. 5 and 6).

It is more economical to buy a good grade of duck, even at a decidedly higher first cost, than a cheap duck which is of light weight and poorly constructed and which will not prove serviceable.



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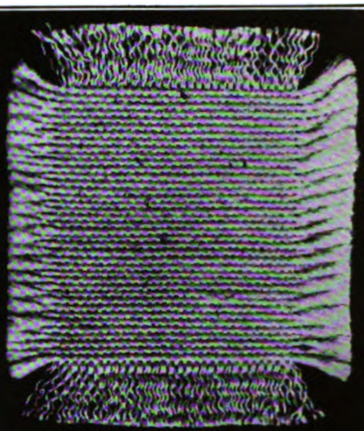

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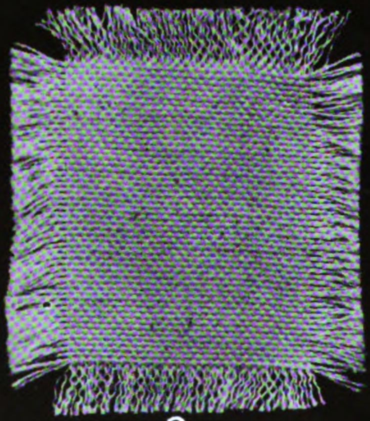

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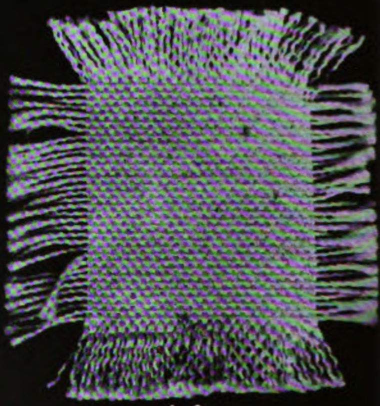

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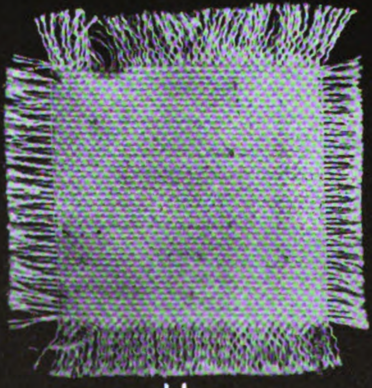

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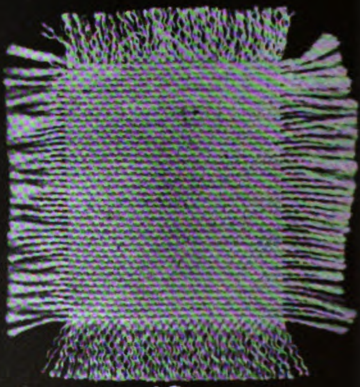

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Fig. 7.—15-ounce double filled duck.
Fig. 8.—15-ounce single filled duck.
Fig. 9.—12-ounce double filled duck.

Fig. 10.—12-ounce single filled duck.
Fig. 11.—10-ounce double filled duck.
Fig. 12.—10-ounce single filled duck.

Duck which when held up to the light shows numerous pinholes or thin places does not make good covers, although a few small pinholes may be permitted. It should be made from multiple-ply yarn and the weave should be medium hard. The ply of the yarns can be determined by untwisting them and counting the number of small threads into which they separate. To ascertain the closeness of the weave, the duck may be unraveled on two adjacent sides and the number of ends of yarn in a measured inch on each side counted. Warp threads run in the long direction of the goods; filling threads run across the goods.

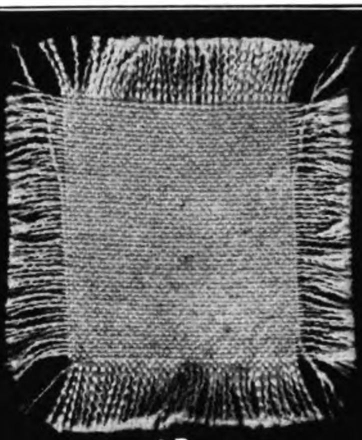
General observation has shown that cotton duck which has been dyed a khaki color with mineral dyes is more water resistant than the white untreated duck. It is also quite mildew resistant and remains so for a long time if the dyeing process has been properly conducted. Unless the canvas is to be subjected to a proofing treatment, it is recommended that only mineral-dyed khaki canvas be bought for severe service. A khaki color may be obtained also by the use of organic dyes, but the mineral-dyed fabric is much to be preferred. The following very simple test will suffice to determine whether the fabric has been dyed with organic dyes or with mineral dyes:

Burn a piece of the duck until no carbon is left in the ash. If mineral dyes have been employed, an appreciable amount of ash, colored from buff to dark brown, will be present, whereas if organic dyes have been used, only a small amount of a white to gray ash will remain.

CARE OF COTTON DUCK.

Because of the greatly increased world consumption of cotton and the enormous crop losses caused by the boll weevil during the past few years, the present demand for high-grade cotton is barely met by the supply. As a result the cost of cotton goods, and particularly that of heavy ducks made from the better grades of cotton, is very high. It is, then, a matter of both national and personal economy to conserve the supply of cotton; and by proper care to make cotton duck last as long as possible.

The deterioration of cotton duck is due to a number of causes, the chief one being mildew, which usually appears when the canvas remains damp for several days in warm weather. Mildew is readily recognized by the appearance on the canvas of white, black, yellow, pink, or green spots, varying in size from that of a pinhead to that of a 5-cent piece. Canvas may be injured also by bacterial action, which produces no marked change in the color but weakens the entire fabric. This occurs when the canvas has lain for some time in contact with the ground or a damp floor. In addition canvas may



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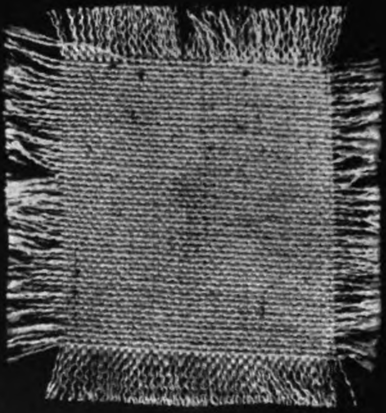

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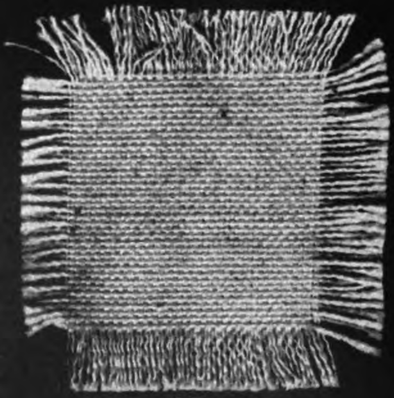

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Fig. 13.—8-ounce U. S. standard Army duck.
Fig. 14.—8-ounce double filled duck.
Fig. 15.—8-ounce single filled duck.

be weakened by the chemical action of materials in it or by the action of air and moisture alone under the influence of sunlight.

White untreated cotton duck mildews very quickly under certain conditions, such as warmth, absence of light, and a moist atmosphere. Canvas which is folded and stored wet or even slightly damp usually is more or less mildewed when taken out, especially if it has been put in a rather warm, dark place. Such canvas is much weakened and leaks in the mildewed places, so that if not totally useless when first taken out it soon becomes so in service and must be replaced.

Canvas which has become wet or even damp should be dried as soon as possible by being spread out over a wagon or hung over a wooden fence or a large pole, preferably in the sunshine, until it is thoroughly dry. If the weather is wet, it may be hung under a shed or in the barn. No canvas, bags, etc., should be folded or stored while damp. Folding of heavy canvas, especially if it has been stiffened by a waterproofing treatment or by being wet or frozen, may weaken or crack the fabric, causing it to leak. For this reason heavy canvas when not in use should hang over a beam or large horizontal pole, or should be suspended against the inside of a barn or shed rather than folded.

WATERPROOFING AND MILDEWPROOFING COTTON DUCK.

Cotton duck, or canvas, which has been given no special treatment sheds water to some extent as long as it does not mildew, especially if it is closely woven and shows but few pinholes when held up to the light. Its water resistance in the untreated condition is sufficient for awnings, pavilions, fixed wagon covers, tents, large umbrellas, or other uses where the fabric is not in a horizontal position and where it is not in contact with objects beneath it. Untreated canvas does not owe its serviceability for such purposes to the fact that it does not become wet. Except in the case of new and unbleached fabrics, where the natural oils and waxy substances of raw cotton fiber as well as oils applied to the yarn during spinning and weaving are still present, cotton fabrics have high water absorption, and canvas used for any of the purposes mentioned will be found to be soaked with water after a rain.

In general, it may be said that the danger from mildew increases with the tendency of the canvas to become wet, unless some substance which is decidedly poisonous to mildew is present. Where the wet canvas remains exposed to the light and air so that it can dry in a reasonably short time, there is little necessity for treatment to prevent mildew. In humid climates or seasons, or under conditions of service where the canvas remains wet or moist for several days at a time, however, treatments which will decrease the rate of water absorption, at the same time decreasing the susceptibility to mildew, should be applied. Another reason for applying waterproofing treatments is that untreated canvas brought in contact, especially moving contact, with objects beneath it does not shed water satisfactorily.

White untreated canvas remains serviceable for from one to five years, or occasionally longer, depending upon its quality, the conditions under which it is used, and the care taken to keep it from mildewing. As previously stated, canvas dyed a khaki color with mineral dyes lasts longer than white untreated canvas under the same conditions. Since it is sometimes difficult to obtain khaki-colored canvas and not always possible to exercise proper and timely care of canvas articles, treatments which will increase the serviceability of white duck are desirable. Proper treatments increase the usefulness and more than double the period of serviceability of white canvas. Treated canvas and commercial preparations for treating canvas may sometimes be obtained from tent and awning dealers, but should never be purchased without some satisfactory evidence of the merit of such treatments.

The most common of the several existing types of waterproofing processes are: (1) Those in which the water resistance is due to insoluble metallic soaps or other insoluble metallic compounds, as, for example, aluminum soap, acetate of aluminum, mineral khaki, and cuprammonium treatments; (2) those depending upon the use of paraffin or mixed waxes; (3) those depending upon the use of bituminous materials, such as asphaltum or tar; (4) those depending upon the use of linseed oil or other drying oils; (5) those where combinations of the processes of types 1, 2, 3, and 4 are used.

By some treatments, such as the cuprammonium, substances which are poisonous to mildew growth are left on the canvas. Practically complete mildew resistance may be obtained by means of the cuprammonium treatment, but this treatment and many others are not adapted to home application. Mildew resistance can be secured best in home treatments by the application of materials which are effective waterproofing agents but contain no food for the mildew organisms, or by the incorporation in the waterproofing materials of fungicides which retard decidedly the development of mildew growth. Some waterproofing treatments, particularly those in which raw drying oils or semidrying oils, such as linseed and cottonseed, are used, should be avoided, as they cause a deterioration in the strength of the fabric and also render the treated canvas liable to spontaneous combustion. It is advisable also to avoid treatments with hard paraffin wax, as they give canvas undesirable physical properties which seem to make it more, rather than less, susceptible to the action of mildew.

FORMULAS.

After thorough tests, both in the laboratory and in the field, the department has found that the following formulas, which have been developed in the course of its investigations, are very satisfactory for increasing the serviceability of cotton duck. It is believed that they will meet the requirements of the farmer and ranchman and others using canvas for outdoor purposes. These formulas are designed solely for use in waterproofing and mildewproofing treatments. While the department believes that the formulas here given do not infringe on any existing patents or pending applications for patents, it can assume no responsibility in the matter.

FORMULA 1.

	Pounds.
Amorphous mineral wax or crude petrolatum	7½
Yellow beeswax	1
Refined Bermudez Lake asphalt	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 2.[1]

	Pounds.
Petroleum asphalt (medium hard) or Bermudez asphalt	6
Neutral or extracted wool grease	2½
Lead oleate, technical	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 3.

	Pounds.
Amorphous mineral wax or crude petrolatum	8½
Yellow beeswax	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 4.

	Pounds.
Amorphous mineral wax or crude petrolatum	6½
Yellow beeswax	1½
Lead oleate, technical	2

Solvent: 3 gallons gasoline and 2 gallons kerosene.

Applications of mixtures made by formulas 1 and 2 give the canvas a dark brownish color, while those made according to formulas 3 and 4 give it a light buff to khaki color. The first two are preferable for all purposes where a dark color is not objectionable.

The amorphous wax referred to in the formulas is a soft grease-like mineral " wax " obtained as a by-product in refining chilled cylinder-oil stocks by means of centrifugal machines, and is very similar to dark petrolatum, except that it is more viscous and has a higher melting point. The substitution for it of dark or amber petrolatum will not materially change the results. Lead oleate is an insoluble metallic soap, which is added to insure waterproofness as well as mildewproofness. The kerosene is added not only to decrease the cost, but to reduce the volatility of the solvent, thus making the mixture spread better. All of these materials may be purchased, but not always from local dealers. Amorphous mineral wax or crude petrolatum (sometimes called petroleum grease) may be secured from dealers in oils and greases. The asphalts are obtainable from dealers in roofing materials. At present it probably is impossible to buy the wool grease from local dealers. This material, as well as amorphous mineral wax, however, may be ordered from wholesale dealers in oils and greases or tanners' supplies, through hardware stores, or through dealers in agricultural supplies and implements. Lead oleate, which also is not sold by small dealers, must be ordered from manufacturers of chemicals through local druggists or paint dealers, who will also supply beeswax.

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[1] This formula was devised on July 28, 1919. Subsequent to that date, on September 30, 1919, U. S. Patent No. 1,317,469 was issued to R. R. Adams, covering the use of wool grease as an " oleaginous ingredient " of a paint, the wool grease being added for the purpose of increasing the adhesive properties, the flexibility, and the luster. Formula 2 is intended to be used for waterproofing and mildewproofing purposes, and not as a paint. It differs from a paint in its general composition and also in that when applied to one side of canvas it does not simply form a surface coating but thoroughly impregnates the fabric so that both sides are substantially alike.

MIXING THE MATERIALS.

Weigh out the solid materials in proper proportions, place them in a kettle or can, and melt slowly and carefully at as low a temperature as possible, with constant stirring. When the mixture has completely melted, *remove to a safe distance from the fire*, and pour it slowly, with constant stirring, into the proper quantity of solvent (a mixture of 3 parts by volume of gasoline and 2 parts by volume of kerosene), using 5 gallons of this solvent to 10 pounds of the mixture. This should be done with free ventilation, preferably out of doors.

In the preparation of mixtures by formulas 1 and 2 there is sometimes a separation of asphalt that does not mix uniformly with the solution upon stirring or shaking. In such cases allow the mixture to stand a day or so, with occasional stirring, before applying it to the canvas. In other cases where the material settles to the bottom of the container or thickens it will be necessary to warm the mixture just before applying it to the canvas. This must be done in the open air by *placing the open container in a tub or can of hot water*. Be sure that the container is open, and *NEVER PLACE IT OVER OR NEAR A FLAME.*

APPLICATION.

The mixture must be thoroughly stirred before and during application, in order to keep the undissolved material in suspension. These preparations may be applied to the canvas by means of a paint brush or by spraying. Wagon covers, shock covers, etc., may be treated best by stretching the canvas against the side of a barn or attaching it to a frame and applying the material with a brush. Once the canvas is fixed in position, no more time is required to treat it than is necessary to apply a first coat of paint to a rough board siding having the same area. Much time may be saved in treating large paulins and standing tents by applying the material with a spray pump, with which a pressure of at least 50 pounds is developed. Some loss of material, however, results from this method.

The experience of the department has been that one coat applied to one side of the canvas usually is sufficient. When one coat is applied to one side, using the strength of solution as given in the formulas, there will be an increase in weight of from 3½ to 4½ ounces per square yard. Ten pounds of the material and 5 gallons of the solvent will treat about 40 square yards of canvas.

COST OF WATERPROOFING AND MILDEWPROOFING COTTON DUCK.

Based on the lowest prices current in Washington, D. C., in August, 1920, the cost of the materials called for in the formulas here given has been estimated to be as follows:

	Materials furnished.	
	Retail.	Whole-sale.
Formula 1	$3.30	$2.80
Formula 2	2.70	2.45
Formula 3	3.80	3.10
Formula 4	4.30	3.50

This cost is calculated for about 6¼ gallons of the mixture, which would cover about 40 square yards of canvas; that is, the cost of the treatments would vary from about 7 to about 11 cents a square yard. The cost of preparing the mixture by formula 2 is reduced by about 25 cents when extracted wool grease is substituted for the neutral wool grease first specified.

The prices on which these estimates were based are as follows:

	Retail.	Whole-sale.
Amorphous mineral wax or crude petrolatum (per pound)	$0.15	$0.10
Yellow beeswax (per pound)	.75	.60
Bermudez Lake asphalt (per pound)	.04	.04
Petroleum asphalt (per pound)	.02	.02
Neutral wool grease (per pound)	.25	.20
Extracted wool grease (per pound)	.15	.10
Lead oleate, technical (per pound)	.40	.30
Gasoline (per gallon)	.31	.31
Kerosene (per gallon)	.22	.22

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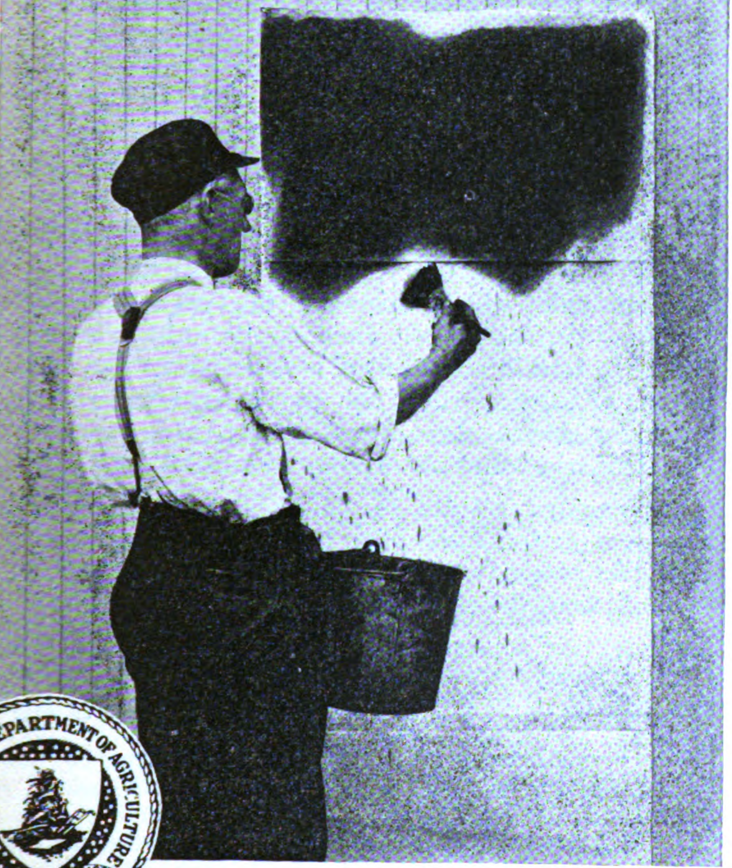
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1157

WATERPROOFING AND MILDEWPROOFING OF COTTON DUCK



UNIVERSITY

ONLY unbleached, unsized, closely woven duck should be used for farm purposes, and unless the canvas is to be subjected to a proofing treatment, it is recommended that only mineral-dyed khaki be bought for out-of-door use.

It is more economical to buy a good grade of duck, even at a decidedly higher first cost, than a cheap duck of light weight and poor construction.

Mildew and sunlight are the chief causes for the deterioration of cotton duck. Untreated duck always mildews in warm weather if stored wet or even slightly damp. To prevent mildewing, the canvas should be thoroughly dried in the open air before it is folded and stored. Sunlight causes rapid deterioration of untreated duck and even more rapid deterioration of duck subjected to certain treatments. Pigments tend to prevent such deterioration.

Treatments which decrease the absorption of water by canvas usually increase its mildew resistance. In humid climates or seasons, or under conditions of service where the canvas remains wet or moist for several days at a time, a treatment which will decrease water absorption should be applied.

Satisfactory results for increasing the serviceability of cotton duck have been obtained with the formulas given in this bulletin. One coat applied to one side of the canvas usually is sufficient.

Washington, D. C. **Issued October, 1920; revised July, 1931**

WATERPROOFING AND MILDEWPROOFING OF COTTON DUCK

By H. P. Holman, *Senior Chemist*, and T. D. Jarrell, *Associate Chemist, Industrial Farm Products Division, Chemical and Technological Research, Bureau of Chemistry and Soils*

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USE OF COTTON DUCK

COTTON DUCK, otherwise known as canvas, is used extensively for the protection of machinery, sacked grain, shocks, stacks and ricks, for wagon and truck covers, for awnings and temporary shelters, for horse covers, and for catching grain which falls to the ground during threshing. Undoubtedly it would be used to a greater extent if it fulfilled more effectively these various purposes and if it retained its serviceability for a longer period than it ordinarily does.

This bulletin tells how to select and care for duck or canvas on the farm and describes simple methods for prolonging its period of serviceability by the application of waterproofing and mildewproofing treatments.

CLASSES OF COTTON DUCK

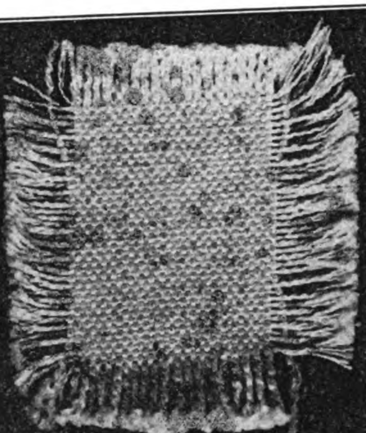
Two general classes of cotton duck are known to the cotton-goods trade. They are " numbered duck " and " ounce duck."

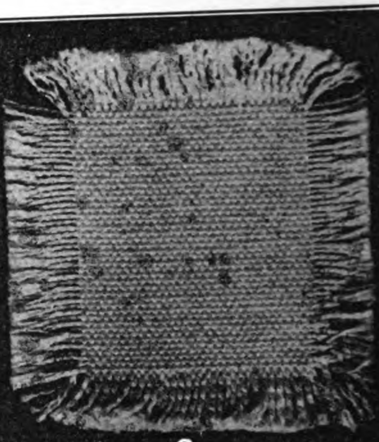
" Numbered ducks " are made of multiple-ply yarns in both the warp and filling directions. The numbers run down, and the weights up, from 12 to 0 (or more ciphers), with a difference in weight between the consecutive numbers of 1 ounce per linear yard 22 inches wide. The canvas can be bought in widths of from 22 to 144 inches. No. 12 duck, which is the lightest of this class, weighs 7 ounces per linear yard 22 inches wide, or about 11.5 ounces per square yard. No. 00 duck, the heaviest commonly used, weighs 20 ounces per linear yard 22 inches wide, or about 32.7 ounces per square yard.

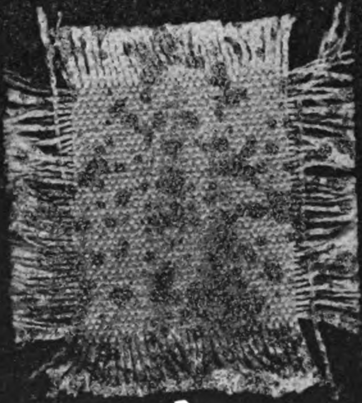
" Ounce ducks " are usually from 28½ to 30 inches wide and weigh from 6 to 15 ounces per linear yard. There are three grades or qualities of ounce ducks:

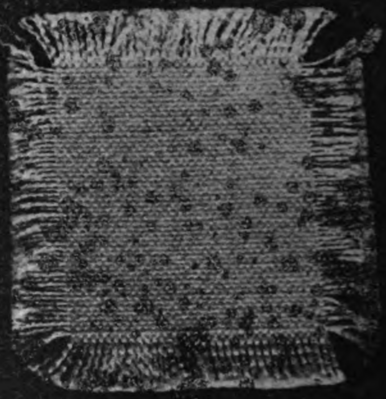
(1) **United States standard Army duck.**—This is the best grade of light and medium-weight duck on the market. It is made of multiple-ply yarns both in the warp and filling directions, and is not bleached, loaded, or sized. (Figs. 2, 4, 6, and 13.)

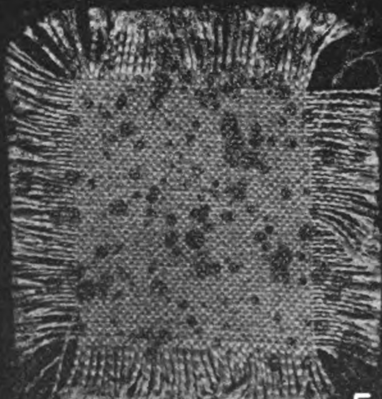
(2) **Double-filled duck.**—The warp consists of single-ply yarns and the filling of multiple-ply yarns. (Figs. 7, 9, 11, and 14.)











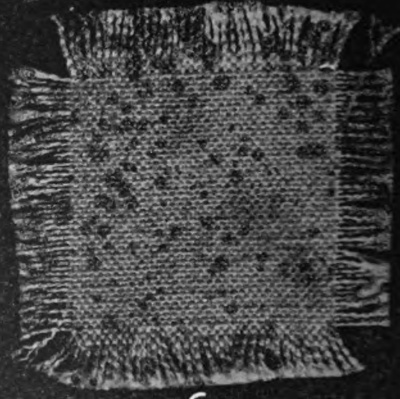


FIGURE 1.—No. 8 duck
FIGURE 2.—15-ounce United States standard Army duck
FIGURE 3.—No. 10 duck

FIGURE 4.—12-ounce standard Army duck
FIGURE 5.—No. 12 duck
FIGURE 6.—10-ounce United States standar Army duck

(3) **Single-filled duck.**—Both the warp and filling are made of single-ply yarns. This is the cheapest and poorest grade of duck on the market. (Figs. 8, 10, and 15.)

In both the double-filled and single-filled ducks the filling yarns are much heavier than the warp yarns. In order to make a canvas of more uniform appearance, therefore, the warp yarns are usually woven in pairs, resulting in a loosely woven duck which has little water resistance and can not be as thoroughly waterproofed as the multiple-ply ducks.

Moreover, the sizing used in weaving these ducks with single-ply warp adds temporary weight to the fabric, which is soon lost on weathering, and increases its water-absorption and susceptibility to mildew. For these reasons, such ducks are not recommended for out-of-door use.

SELECTION OF COTTON DUCK FOR FARM USE

For farm purposes only bleached, unsized, closely woven duck should be used. It should not be too stiff, however, nor so closely woven that it has no flexibility when wet and cold, in which case it has a tendency to crack when creased or folded. Furthermore, stiff canvas is very difficult to handle, and, when used as a cover, does not shape itself properly to objects, as a result of which it does not give them adequate protection. For horse covers a moderately stiff canvas is preferable, as it does not lie close to the body of the animal and does not cause sweating as readily as the more flexible material.

Large covers or paulins.—These should be made of No. 8 duck, which weighs about 18 ounces per square yard, or of 15-ounce United States standard Army duck, weighing about 18.9 ounces per square yard. (Figs. 1 and 2.)

Wagon and machine covers.—Either No. 10 or 12-ounce United States standard Army duck is suitable for this purpose, as both have sufficient body without being too stiff when wet. No. 10 duck weighs about 14.7 ounces and 12-ounce United States standard Army duck about 15.2 ounces per square yard. (Figs. 3 and 4.)

Hay caps and other small covers.—No. 12 duck, weighing about 11.5 ounces per square yard, or 10-ounce United States standard Army duck, weighing 12.6 ounces per square yard, is satisfactory for this purpose. (Figs. 5 and 6.) Although not so durable, lighter-weight fabrics such as 7-ounce or 8-ounce khaki Army duck, or even closely woven unbleached sheeting that has been waterproofed, can be used for hay caps.

Awnings.—Eight-ounce duck is sufficiently heavy for this purpose. Khaki Army duck, either plain or decorated with painted stripes, is more serviceable than ordinary awning ducks.

Tents.—Ten-ounce United States standard Army duck is suitable for medium-sized tents that are used occasionally for comparatively short periods of time. For large tents or tents that are used continuously 12-ounce Army duck is more serviceable. Shelter-tent duck is very suitable for lightweight auto tents.

It is more economical to buy a good grade of duck, even at a decidedly higher first cost, than a cheap duck which is poorly constructed and will not prove serviceable.

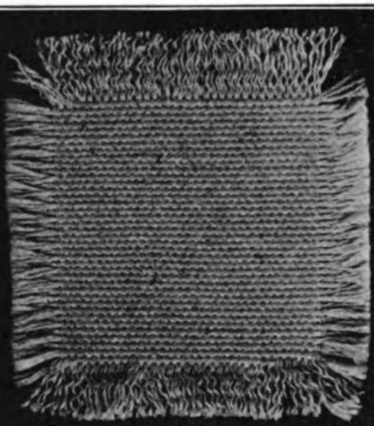


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FIGURE 7.—15-ounce double-filled duck

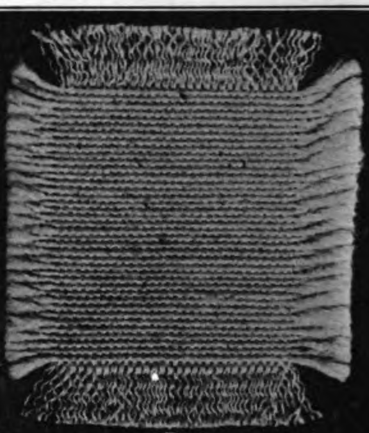

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FIGURE 8.—15-ounce single-filled duck

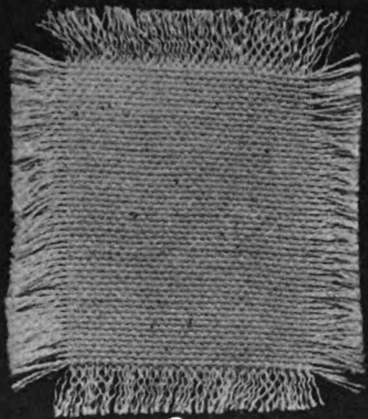

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FIGURE 9.—12-ounce double-filled duck

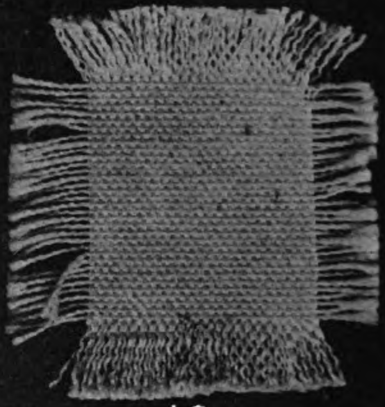

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FIGURE 10.—12-ounce single-filled duck

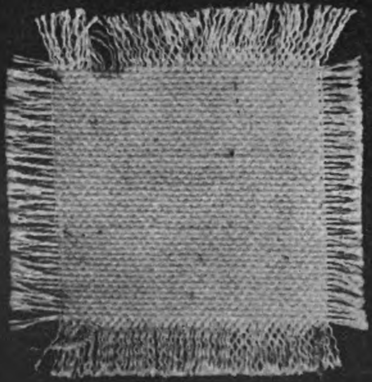

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FIGURE 11.—10-ounce double-filled duck

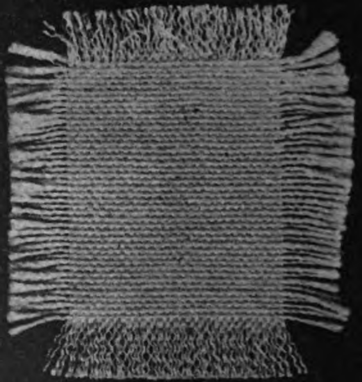

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FIGURE 12.—10-ounce single-filled duck

Duck which when held up to the light shows numerous pinholes or thin places does not make good covers, although a few small pinholes may be expected. The best duck is made from multiple-ply yarn, and the weave is moderately hard. The ply of the yarns can be determined by untwisting them and counting the number of small threads into which they separate. To ascertain the closeness of the weave, the duck may be unraveled on two adjacent sides and the number of ends of yarn in a measured inch on each side counted. Warp threads run in the long direction of the goods; filling threads run across the goods.

General observation has shown that cotton duck which has been dyed a khaki color with mineral dyes is more durable than the white untreated duck. It is somewhat mildew resistant and remains so for a long time if the dyeing process has been properly conducted. Unless the canvas is to be subjected to a proofing treatment, it is recommended that only mineral-dyed khaki canvas be bought for severe service. A khaki color may be obtained also by the use of organic dyes, but the mineral-dyed fabric is much to be preferred. The following very simple test will suffice to determine whether the fabric has been dyed with organic dyes or with mineral dyes:

Burn a piece of duck until no carbon is left in the ash. If mineral dyes have been used, an appreciable amount of ash, colored from buff to dark brown, will be present; if organic dyes have been used, only a small amount of a white to gray ash will remain.

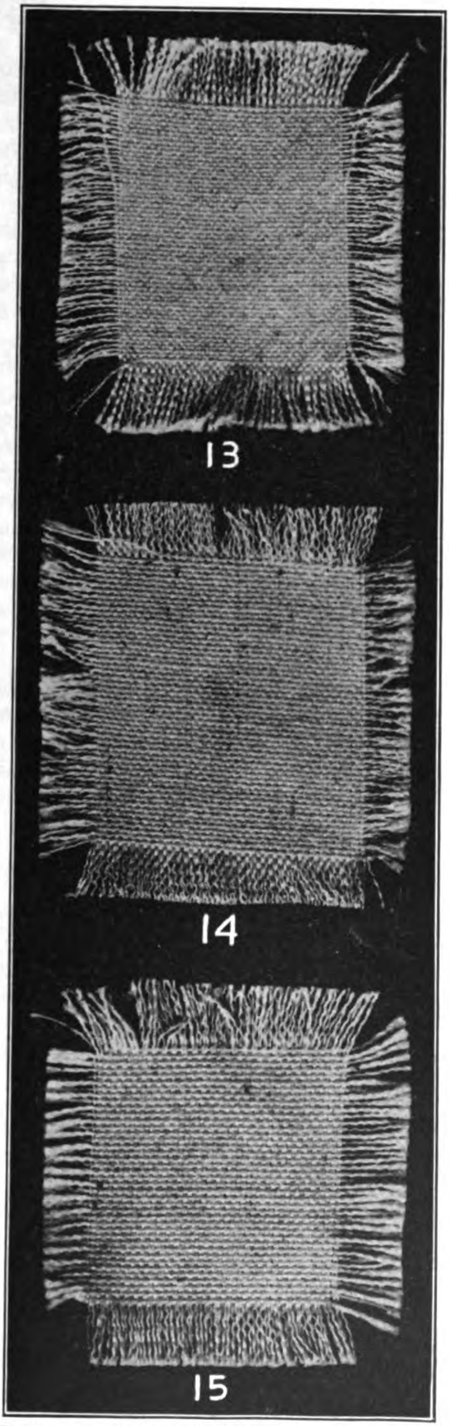

FIGURE 13.—8-ounce U. S. standard Army duck
FIGURE 14.—8-ounce double-filled duck
FIGURE 15.—8-ounce single-filled duck

CARE OF COTTON DUCK

The deterioration of cotton duck is due to a number of causes other than use. One is mildew, which usually appears when the canvas remains damp for several days in warm weather. Mildew is readily recognized by the appearance on the canvas of white, black, yellow, pink, or green spots, varying in size from that of a pinhead to that of a 5-cent piece. Canvas may be injured also by bacterial action, which produces no marked change in the color but weakens the entire fabric. This occurs when the canvas has lain for some time in contact with the ground or a damp floor. In addition canvas may be weakened by the chemical action of materials in it or simply by exposure to sunlight.

White untreated cotton duck mildews very quickly under certain conditions, such as warmth, absence of light, and a moist atmosphere. Canvas which is folded and stored wet or even slightly damp usually is more or less mildewed when taken out, especially if it has been put in a rather warm, dark place. Such canvas is much weakened and leaks in the mildewed places, so that if not totally useless when first taken out it soon becomes so in service and must be replaced.

Canvas which has become wet or even damp should be dried as soon as possible by being spread out over a wagon or hung over a wooden fence or a large pole, preferably in the sunshine, until it is thoroughly dry. If the weather is wet, it may be hung under a shed or in the barn. No canvas, bags, etc., should be folded or stored while damp. Folding of heavy canvas, especially if it has been stiffened by a waterproofing treatment or by being wet or frozen, may weaken or crack the fabric, causing it to leak. For this reason heavy canvas when not in use should hang over a beam or large horizontal pole, or should be suspended against the inside of a barn or shed rather than folded.

WATERPROOFING AND MILDEWPROOFING COTTON DUCK

Cotton duck, or canvas, which has been given no special treatment sheds water to some extent as long as it does not mildew, especially if it is closely woven and shows but few pinholes when held up to the light. Its water resistance in the untreated condition is sufficient for awnings, pavilions, fixed wagon covers, tents, large umbrellas, or other uses where the fabric is not in a horizontal position and where it is not in contact with objects beneath it. Untreated canvas does not owe its serviceability for such purposes to the fact that it does not become wet. Except in the case of new and unbleached fabrics, where the natural oils and waxy substances of raw cotton fiber as well as oils applied to the yarn during spinning and weaving are still present, cotton fabrics have high water absorption, and canvas used for any of the purposes mentioned will be found to be soaked with water after a rain.

In general, it may be said that the danger from mildew increases with the tendency of the canvas to become wet, unless some substance which is decidedly poisonous to mildew is present. Where the wet canvas remains exposed to the light and air, so that it can dry in a reasonably short time, there is little necessity for treatment to prevent mildew. In humid climates or seasons, or under conditions of service where the canvas remains wet or moist for several days at a time, however, treatments which will decrease the rate of water absorption, at the same time decreasing the susceptibility to mildew, should be applied. Another reason for applying waterproofing treatments is that untreated canvas brought in contact, especially moving contact, with objects beneath it does not shed water satisfactorily.

White untreated canvas remains serviceable for from one to five years, or occasionally longer, depending upon its quality, the conditions under which it is used, and the care taken to keep it from mildewing. As previously stated, canvas dyed a khaki color with mineral dyes lasts longer than white untreated canvas under the same conditions. Since it is sometimes difficult to obtain khaki-colored canvas and not always possible to exercise proper and timely care of canvas articles, treatments which will increase the serviceability of white duck are desirable. Proper treatments increase the usefulness and more than double the period of serviceability of white canvas. Treated canvas and commercial preparations for treating canvas may sometimes be obtained from tent and awning dealers, but should never be purchased without some satisfactory evidence of the merit of such treatments.

The most common of the several existing types of waterproofing processes are: (1) Those in which the water resistance is due to insoluble metallic soaps or other insoluble metallic compounds, as, for example, aluminum soap, basic acetate of aluminum, mineral khaki, and cuprammonium treatments; (2) those depending upon the use of paraffin or mixed waxes; (3) those depending upon the use of bituminous materials, such as asphaltum or tar; (4) those depending upon the use of linseed oil or other drying oils; (5) those where combinations of the processes of types 1, 2, 3, and 4 are used.

By some treatments, such as cuprammonium, substances which are poisonous to mildew growth are left on the canvas. Practically complete mildew resistance may be obtained by means of the cuprammonium treatment, but this treatment and many others are not adapted to home application. Mildew resistance can be secured best in home treatments by the application of materials which are effective waterproofing agents but contain no food for the mildew organisms, or by the incorporation in the waterproofing materials of fungicides which retard decidedly the development of mildew growth. Among such fungicides the most readily available are dry Bordeaux mixture and Paris green, but the use of these substances is attended with considerable danger, as they may dust off the fabric and be inhaled or contaminate foodstuffs. It is advisable to avoid treatments with paraffin wax, as they give canvas undesirable physical properties which seem to make it more, rather than less, susceptible to the action of mildew.

It has been found that some waterproofing treatments, particularly those in which materials of an oily, greasy, or waxy character are used, cause cotton duck to lose strength very rapidly when exposed to sunlight. Untreated 12-ounce Army duck may lose about 40 per cent of its strength as a result of exposure to the weather for six months during the warmer part of the year. Duck treated with linseed oil may lose 65 per cent or more of its strength when similarly exposed, and duck treated with materials consisting mostly of paraffin, petrolatum, or petroleum grease may lose from 80 to 90 per cent of its strength when exposed under the same conditions. Canvas treated with waterproofing preparations containing certain pigments such as lampblack and the earth pigments (ocher, sienna, and umber) does not lose so much of its strength when exposed to the weather. For this reason it is advisable to add an opaque pigment to any waterproofing preparation to be used on canvas that will be exposed to the weather continuously or frequently. If a commercial preparation is to be used it is best to select one that will color the fabric distinctly and permanently.

FORMULAS

In formulas for home use in waterproofing canvas the choice of materials is necessarily limited to those that are generally available or that can be procured in moderately small quantities with little effort and at fairly low cost.

Waterproofing treatments prepared according to the following formulas have been found satisfactory for increasing the serviceability of cotton duck, and it is believed that they will meet the requirements of the farmer and ranchman and others using canvas for outdoor purposes.

For canvas paulins or large portable covers—

FORMULA 1

Petrolatum (vaseline), dark or amber	pounds	8½
Beeswax, yellow refined	do	1½
Earth pigment, dry (ocher, sienna, or umber)	do	5
Volatile mineral spirits (painters' naphtha)	gallons	5

FORMULA 2

Petroleum asphalt, medium hard	pounds	7½
Petrolatum, dark or amber	do	2½
Lampblack, dry	do	1
Volatile mineral spirits (painters' naphtha)	gallons	5

The quantities specified are sufficient to treat about 40 square yards of canvas on one side.

A mixture of 3 gallons of gasoline and 2 gallons of kerosene can be substituted for the volatile mineral spirits, but will evaporate more slowly. Canvas treated according to the first formula will be colored buff by ocher, khaki by raw sienna, drab by raw umber, and brown by burnt umber. If a white treatment is preferred, use dry zinc oxide in place of earth pigment. For some purposes, formula 1 with a light-colored pigment will be preferable to formula 2, because canvas treated with the latter will absorb more heat from sunlight, owing to its black color.

For permanently fixed canvas covers—

FORMULA 3

Boiled linseed oil	gallon	1
Lampblack, ground in linseed oil	pounds	2
Japan drier	pint	1

FORMULA 4

Boiled linseed oil	gallon	1
Aluminum bronzing powder	pound	1
Japan drier	pint	½

For lightweight fabrics not continuously or frequently exposed to sunlight—

FORMULA 5

Beeswax, yellow refined	pound	½
Spirits of turpentine	gallon	1

Petrolatum and beeswax can be purchased from druggists or from wholesale dealers in druggists' supplies. Petroleum asphalt can sometimes be supplied by dealers in roofing materials or can be ordered from refiners of asphaltic base petroleum. The other materials specified in the formulas can be obtained from paint stores.

MIXING THE MATERIALS

In the preparation of waterproofing solutions according to formulas 1, 2, and 5, place the specified weights of waterproofing materials in a suitable metal container and melt slowly and carefully at as low a temperature as possible, with constant stirring. Then remove to a place where there is good ventilation and no fire or open flame and pour the melted material into the solvent while stirring. When a pigment is used, thin the pigment in a separate container by mixing with it small additions of the liquid, and when the pigment mixture is sufficiently thinned strain it through fine-mesh wire screen or several thicknesses of cheesecloth into the waterproofing liquid. In formulas 3 and 4 the pigments should be thinned in a similar manner with linseed oil before they are added to the bulk of the oil.

When the waterproofing material settles to the bottom of the container or thickens, it will be necessary to warm the mixture just before applying it to the canvas. This must be done in the open air by placing the container in a tub or can of hot water. Be sure that the container is open, and *never place it over or near a flame.*

APPLICATION

The mixture must be thoroughly stirred before and during application, in order to keep the undissolved material in suspension. These preparations may be applied to the canvas by means of a paint brush or by spraying. Wagon covers, shock covers, etc., may be treated best by stretching the canvas against the side of a barn or attaching it to a frame and applying the material with a brush. Once the canvas is fixed in position, no more time is required to treat it than is necessary to apply a first coat of paint to a rough board siding having the same area. Much time may be saved in treating large paulins and standing tents by applying the material with a spray pump, with which a pressure of at least 50 pounds is developed. Some loss of material, however, results from this method.

The experience of the Department of Agriculture has been that one coat applied to one side of the canvas usually is sufficient. With one coat applied to one side, using the strength of solution as given in the formulas, there will be an increase in weight of approximately 40 to 50 per cent when formula 1 or 2 is used. When formula 3 or 4 is used the fabric will gain about 75 per cent in weight. When formula 5 is used the gain in weight will be around 10 per cent.

When canvas is treated with linseed-oil preparations it should be allowed to dry thoroughly (for two or three weeks) while freely exposed to the air. If folded and stored in a warm place before drying is complete the accumulated heat from continued oxidation may result in spontaneous combustion.

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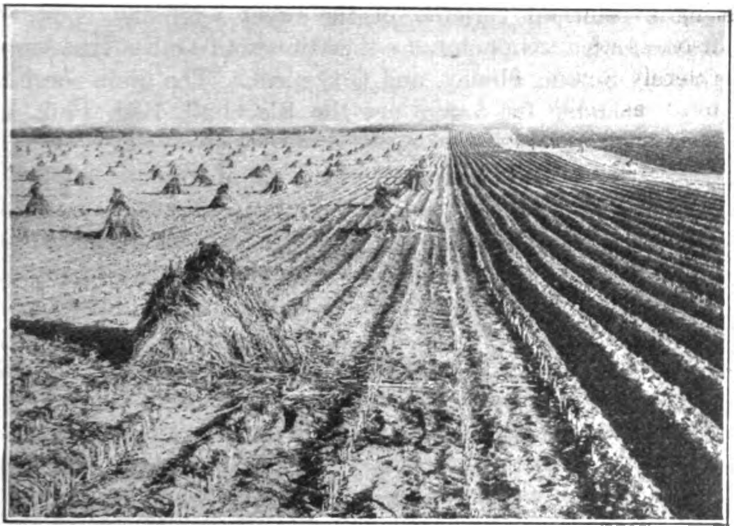

Red Amber Sorgo in Shock in December at Hays, Kans.

FARMERS' BULLETIN 1158

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. November, 1920

WASHINGTON : GOVERNMENT PRINTING OFFICE : 19

SORGHUMS are for the most part native of Africa, and most of the varieties now grown in the United States originated on that continent.

It is estimated that in 1918 more than 5,000,000 acres of sorghum were grown for forage in the United States. Most of this acreage was located in the Southeastern States and in the southern half of the Great Plains.

The principal varieties of the sweet sorghums, considered from a forage standpoint, are the Minnesota Amber, Red Amber, Orange, Sumac, Honey, and Gooseneck. The grain sorghums most valuable for forage are the Blackhull, Red, Pink, and Dwarf kafirs.

There is little difference in the yield of sorghum planted in rows 40 inches apart and that sown in close drills, but the cultivated rows are most dependable in seasons of low rainfall.

Sorghum which has matured, or at least headed, not only makes a better quality of fodder, but is less dangerous to pasture.

Sorghum varieties hybridize freely, and lack of uniformity can be prevented only by constant attention to the purity of the seed used. Each farmer should select in the field the seed intended for his own plantings.

Sorghum is most useful as a hay crop in the Southern States because of its certainty of producing a crop and on account of the failure of ordinary hay crops, such as timothy and alfalfa, in that section.

Both the sweet sorghums and the grain sorghums are excellent silage crops. Stockmen in the Great Plains area can avoid the loss of thousands of cattle by feeding sorghum silage which has been stored at a small expense in pit silos.

The most serious disadvantage in the use of sorghums as a pasture or soiling crop is the danger of prussic-acid poisoning, for which no effective remedy has been discovered.

GROWING AND UTILIZING SORGHUMS FOR FORAGE.

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IMPORTANCE OF THE SORGHUM CROP.

THE SORGHUMS are for the most part native of tropical Africa. Over 1,200 separate lots of sorghum seed have been received from foreign countries, but the most important single shipment is probably that of 16 varieties from Natal, South Africa, in 1857. At first, most attention was devoted to the growing of sorghum as a source of sirup and sugar. The settlement of the prairie lands in the semiarid West created a demand for drought-resistant forage crops, and Kansas alone now harvests a larger acreage of sweet sorghums for forage than the total acreage grown in the United States for sirup. It is estimated that at least 5,000,000 acres of sorghum were used for fodder and silage in the United States in 1918.

This bulletin treats of the culture and utilization for forage both of the sweet sorghums and the grain sorghums. Because of the adaptation of these crops to climatic conditions in the southern Great Plains, it will be most useful in that section, but the information will be found valuable wherever sorghum is grown for forage.

AREAS SUITED TO SORGHUM PRODUCTION.

The principal sorghum-producing areas are illustrated on the map shown as figure 1. In the southern Great Plains sorghum is the most dependable crop. In western Texas, Oklahoma, and Kansas and in eastern New Mexico and Colorado it should form the basis of agriculture in connection with live-stock production. In this region sorghum varieties properly chosen can be depended on both for grain and forage. Except at high elevations, sorghum can, however, be grown as a secondary forage crop in all parts of the United States up to within about 200 miles of the northern boundary.

RELATION OF SORGHUM TO CLIMATE.

The sorghums do best in the southern half of the United States, where the temperatures are uniformly high during the growing season. The most favorable temperature for their growth is perhaps about 90° F., and they grow very little when it is below 60° F.[1] These temperature requirements prevent sorghums from being grown at very high altitudes. The limits of successful production are reached at altitudes of 5,000 to 6,000 feet in Wyoming and Colorado, and at 7,000 feet in Arizona and New Mexico.

Sorghum is not so exacting in its moisture requirements as in its temperature relations. Despite the fact that the largest sorghum area in the United States is in a region of low and uncertain rainfall, the crop thrives where the rainfall is heavy. Sorghum is grown extensively in the semiarid plains, not because a low rainfall is necessary, but because it is more productive than other crops under such conditions.

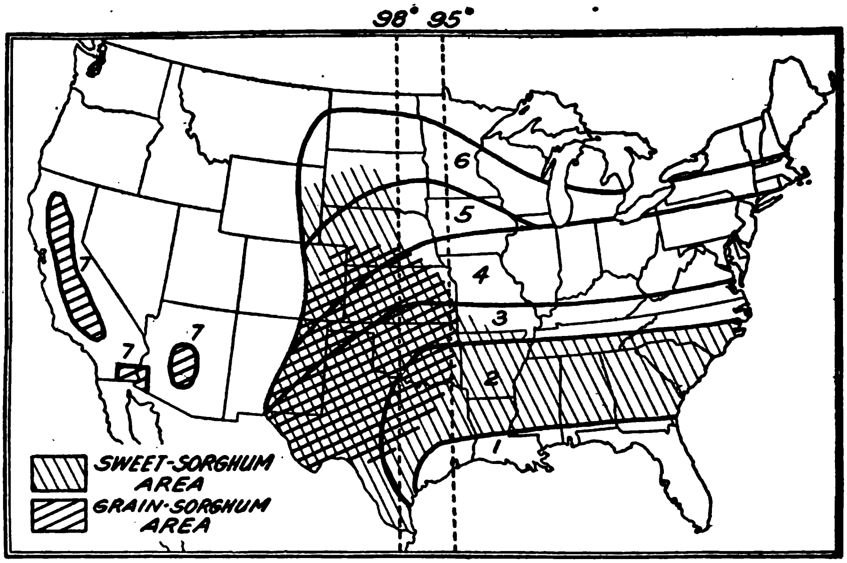

FIG. 1.—Outline map of the United States, showing the principal forage-sorghum areas and the varieties recommended for each. The principal grain-sorghum regions, besides the southern Great Plains, include the Salt River and Yuma Valleys in Arizona and the Imperial, San Joaquin, and Sacramento Valleys in California.

VALUE OF SORGHUM UNDER DROUGHTY CONDITIONS.

The sorghums are of most value in regions of uncertain rainfall because they remain practically dormant during a period of drought and resume growth as soon as there is sufficient rain to wet the soil. In addition, the sorghum plant has almost twice as many secondary roots or feeders per unit of primary root as corn and is thus more efficient in absorbing moisture from the soil. It also has been found that the leaf system or transpiration surface is on the average only about half as great as that of corn. This combination of an efficient absorbing system with a reduced leaf area no doubt accounts in a large degree for the greater ability of the sorghums to withstand drought.[2]

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[1] Vinall, H. N., and Reed, H. R. The effect of temperature and other meteorological factors on the growth of sorghums. *In* Jour. Agr. Research, v. 13, no. 2, p. 133–148, pl. 11–12. 1918. Literature cited, p. 147.

Carefully conducted experiments[3] with corn, milo, and kafir covering a period of six years at Garden City, Kans., and at Amarillo and Dalhart, Tex., show that corn was grown at a loss both at Garden City and Amarillo and returned only a small profit at Dalhart, even when the stover or fodder was assigned a value of $4 per ton. Milo returned a profit at all three stations, varying from $2.07 per acre at Garden City to $11.14 at Dalhart. Kafir did equally well, returning an acre profit of $3.78 at Garden City, $8.21 at Amarillo, and $12.07 at Dalhart. The larger portion of this value in each case was derived from the forage, as in many instances no grain was produced.

The sorghums have fully established their reliability under droughty conditions in the southern Great Plains both for forage and grain. The farmer who continues to grow corn and wheat as his main crops in this sorghum belt is deliberately inviting disaster.

SOIL RELATIONS.

Sorghum thrives on a variety of soils. Deep, fertile sandy loams are best, but fair crops can be produced on heavy clays if they are well drained. Land too poor and thin to grow corn or wheat seldom produces a profitable crop of sorghum. It is not a wise practice to grow sorghum on poor or worn-out lands. A legume, like cowpeas or clover, should be substituted in the crop system and the productive power of the soil restored by applications of commercial fertilizers or barnyard manure.

Sorghum is more tolerant of alkali in the soil than most crops. It is claimed[4] that good crops of fodder can be obtained on soils where the amount of alkali is between 0.4 and 0.6 per cent and that fair crops may be expected on soils with 0.6 to 0.8 per cent of white alkali, but satisfactory grain yields are not often obtained.

EFFECT ON THE LAND.

Sorghum has the reputation of being "hard on the land." This expression is commonly applied by farmers to crops which seem to have an adverse effect on the yields of succeeding crops. The belief that corn, oats, wheat, and other crops yield less on fields that have produced a crop of sorghum the previous year than on fields where the preceding crop was corn or small grain is supported by rotation experiments in Alabama, Arkansas, Kansas, and Nebraska. In these four States the average grain yield of the above crops after corn was 24.5 bushels and after sorghum 20.7 bushels per acre. This difference of approximately 15 per cent in the yield of the crop following sorghum is sometimes, if not always, balanced by the large yield of sorghum. At the Kansas Agricultural Experiment Station the 3-year average yield of corn after sorghum was 40.8 bushels, corn after kafir 44 bushels, and corn after corn 54.6 bushels per acre. The acre value of the crops in the 2-year rotation, however, was in the first case $31.15; in the second $34.46, and in the third $28.14.

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[2] **Miller, E. C.** Comparative study of the root systems and leaf areas of corn and the sorghums. *In* Jour. Agr. Research, v. 6, no. 9, p. 311-332, pl. 38-44. 1916.

[3] **Chilcott, E. F., Griggs, W. D., and Burmeister, C. A.** Corn, milo, and kafir in the southern Great Plains area: Relation of cultural methods to production. U. S. Dept. Agr. Bul. 242, 20 p. 1915.

[4] **Kearney, T. H.** Choice of crops for alkali lands. U. S. Dept. Agr., Farmers' Bul. 446, 32 p. 1920.

Several factors contribute to the low yield of crops following sorghum. The most important one in the dry regions is probably the rather complete exhaustion of soil moisture by the sorghum. Another is the bad physical condition of the soil resulting from the lack of humus and the difficulty of breaking up the sorghum stubble. Where sorghum has been grown in cultivated rows little vegetable matter is left on the surface of the soil to decay and form humus, and the roots hold on to the soil so tenaciously that the stubble is difficult to break up in the fall and may give some trouble the following spring.

Because of these effects on the soil, fall-sown grain does not usually succeed on a sorghum field. It is best, therefore, to follow sorghum with a spring-sown crop or summer fallow.

USE OF FERTILIZERS.

In the Great Plains, where the larger part of the sorghum acreage is located, most of the plantings are made on comparatively new land, and but little fertilizer is used. The limiting factor in all this region is the rainfall and not soil fertility.

In the Southeastern States any complete fertilizer which is known to be beneficial to corn under local conditions may be expected to prove profitable when applied to sorghum. Where forage is the chief consideration it is desirable to have the nitrogen content of the fertilizer rather high. In the cotton belt it has been a common practice to apply 200 to 300 pounds of cottonseed meal per acre to land that is to be planted to sorghum.

CLASSIFICATION OF SORGHUM VARIETIES.

The sorghums may be divided into four broad groups: (1) Sorgos, or sweet sorghums, (2) grain sorghums, (3) grass sorghums, and (4) broom corns. The first group includes those varieties with sweet, juicy stems and seeds of little value for feeding as grain on account of the high tannin content. The second group includes varieties with pithy or only slightly juicy stems, but producing grain comparatively free from tannin and therefore of high feeding value. The third group are leafy, fine-stemmed sorghums, like Sudan grass, useful principally as hay plants. In the fourth group, also, the plants have dry, pithy stems, but are characterized chiefly by their long, loose panicles, or heads, which are utilized in the manufacture of brooms. Only the first two groups will be considered in this publication, as the broom corns are unimportant from the standpoint of forage production. The broom corns, the grass sorghums, and sorghums for sirup production are treated in separate publications.[5]

The sweet sorghums, often called "cane" by farmers, are used only for forage and sirup. In this publication the name sorgo is used to denote the sweet sorghums rather than the word "cane," which properly belongs to the sugar canes, an entirely different group of plants, represented by the botanical genus Saccharum. The use of the term "cane" for the sweet sorghums leads to confusion, especially in regions where sugar cane is commonly grown.

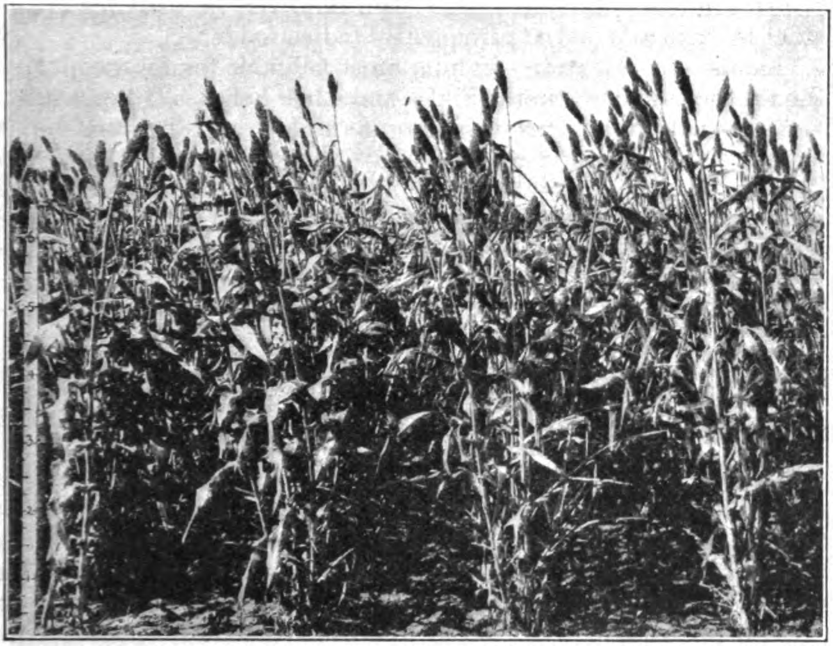

FIG. 2.—A field of Orange sorgo at Hays, Kans. This is one of the best varieties for silage in eastern Kansas.

An accurate estimate of the number of sorgo varieties is impossible. The most important ones are the Minnesota or Black Amber, Dakota Amber, Red Amber, Orange (fig. 2), Sumac, Honey (sometimes called "Japanese cane"), and Gooseneck (known also as "Texas Seeded Ribbon cane"). The following varieties are less important or at least less widely grown: Planter, Sourless (also called "White Orange"), Sapling, Colman, Denton, Red X, Collier, Folger (or Folger's Early), McLean, White African, and Dwarf Ashburn.

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[5] Vinall, H. N. Sudan grass. U. S. Dept. Agr., Farmers' Bul. 1126, 30 p., 11 fig. 1920.
Rothgeb, B. E. Dwarf broom corns. U. S. Dept. Agr., Farmers' Bul. 768, 16 p., 7 fig. 1916.
——— Standard broom corn. U. S. Dept. Agr., Farmers' Bul. 958, 20 p., 7 fig. 1918.
Bryan, A. H. Sorghum-sirup manufacture. U. S. Dept. Agr., Farmers' Bul. 477, 38 p., 22 fig. 1918.

Grain sorghums have been treated in numerous publications,[6] but little information has been published as to their forage value. They are of most importance in the southern Great Plains and the irrigated portions of New Mexico, Arizona, and California (see fig. 1). In some grain-sorghum groups, kafir for example, more than 40 per cent of the total acreage is harvested for fodder. In exceptional years, when drought or early frosts prevent its development into a good grain crop, the amount of kafir utilized as forage has been estimated at more than 80 per cent of the acreage in certain States. The percentage of milo and feterita harvested as fodder is always much less than that of kafir, because these crops, having drier stems and fewer leaves, are less palatable. They can, however, be used for silage if occasion demands and are frequently fed as fodder.

The varieties of grain sorghum most valuable for forage purposes are the Blackhull, Dwarf, Pink, and Red kafirs. Other varieties which in some regions are valued quite highly as grain crops but are of minor importance from a forage standpoint are the following: Standard, Dwarf, and White milo and feterita. Still other varieties of less value are the Dwarf hegari, shallu, kaoliang, and Freed sorghum. Two new varieties which are grown only to a limited extent, chiefly in Oklahoma, are the Schrock kafir and Darso sorghum. Neither of these is likely to replace the standard varieties of kafir and milo.

SORGHUM VARIETIES RECOMMENDED FOR DIFFERENT AREAS.

It is fully as important to minimize the effect of adverse climatic conditions by a wise choice of crops as it is to create more favorable conditions by means of irrigation or improved methods of culture. In no part of the United States is the truth of this statement more often confirmed than in the semiarid portion of the Great Plains, where the rainfall is so undependable. The sweet sorghums introduced from South Africa in 1857 and the kafirs and milos introduced more than 20 years later are being recognized as the crop basis of a permanent system of agriculture. Within these groups are many varieties differing in their abilities to endure droughts or to respond generously to abundant rains. An intelligent selection of varieties is the best insurance against failure, and the most reliable varieties for each part of the sorghum area are indicated in the following paragraphs, which refer to the map on page 4.

East of the 98th meridian and north of the lined area shown on the map (fig. 1), timothy and clover are more highly prized than the sorghums for hay, and corn can be depended upon for grain, fodder, and silage. Outside of the regions numbered and described below, sorghum is not well adapted and is of little importance.

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[6] Ball, C. R., and Rothgeb, B. E. Kafir as a grain crop. U. S. Dept. Agr., Farmers' Bul. 552, 19 p., 8 fig. 1913.

—— —— How to use sorghum grain. U. S. Dept. Agr., Farmers' Bul. 972, 18 p., 7 fig. 1918.

Rothgeb, B. E. Shallu, or "Egyptian wheat". U. S. Dept. Agr., Farmers' Bul. 827, 8 p., 2 fig. 1917.

—— Milo, a valuable grain crop. U. S. Dept. Agr., Farmers' Bul. 1147, 19 p., 8 fig. 1920.

Scott, G. A. The feeding of grain sorghums to live stock. U. S. Dept. Agr., Farmers' Bul. 724, 15 p., 5 fig. 1916.

Vinall, H. N., and Ball, C. R. Feterita, a new variety of sorghum. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 122, p. 25–32. 1913.

Region 1.—For forage: Japanese sugar cane should be grown in preference to the sorghums, because it is more productive.

Region 2.—For forage: Sumac, Orange, Honey, and Gooseneck sorgos. For grain and forage: Corn and oats are preferable to the sorghums except in the lined portion of figure 1; there, Blackhull kafir and Dwarf hegari are more dependable than corn except on the river bottoms.

Region 3.—For forage: Sumac and Orange sorgos. For grain and forage: East of the 95th meridian, corn and the small grains; between the 95th and 98th meridians, Blackhull kafir; west of the 98th meridian, Dwarf kafir, Sunrise kafir, and Dwarf milo, with a small acreage of feterita as insurance against drought.

Region 4.—For forage: West of the 98th meridian, Red Amber sorgo; east of the 98th meridian, Orange sorgo. For grain and forage: East of the lined area (fig. 1), corn and the small grains; that portion of the lined area east of the 98th meridian, Blackhull and Pink kafirs on the uplands, corn on the river bottoms; west of the 98th meridian, Dwarf kafir, Pink kafir, Dwarf milo, and feterita.

Region 5.—For forage: Red Amber, Dakota Amber, and Minnesota Amber sorgos. For grain and forage: In all except the lined portion (fig. 1), corn and the small grains; in the lined part, corn, feterita, Freed sorghum, White milo, and Dwarf milo.

Region 6.—For forage: Minnesota Amber, Red Amber, and Dakota Amber sorgos. For grain and forage: Early varieties of corn and the small grains.

Region 7.—For forage: Honey, Gooseneck, and Sumac sorgos. For grain and forage: Dwarf milo, Dwarf hegari, and Blackhull kafir.

The varieties named for the various regions shown on the map (fig. 1) are recommended on the basis of the normal seeding date. When it becomes necessary for any reason to seed after the most favorable date, then it is often desirable to use an earlier maturing variety. For late seeding in region 2 the Orange is preferable to the Sumac, Honey, or Gooseneck; in region 3 the Red Amber and Orange should be used in place of the Sumac; and in regions 4 and 5 the Freed sorghum and Minnesota Amber sorgo often make a better crop than the Red Amber or Orange when planted late in the season. Freed sorghum is particularly suited to such uses and can be used in this way over the entire grain-sorghum area to better advantage than as a regular-season crop.

The sweet sorghums produce a higher yield of forage than the grain sorghums, and the earlier varieties also produce good yields of seed. This seed is of little value as grain, however, on account of the tannin which it contains. Many farmers in the Great Plains prefer a sorghum which can be utilized as a grain crop in seasons of favorable rainfall and yet be utilized for forage if it does not promise a profitable grain yield. Grain sorghums are therefore included in the varieties recommended for the different regions. For forage alone the sorgos are preferable to the grain sorghums, but in many instances the forage is a secondary consideration to the grain, which can be fed on the farm or marketed for cash.

DATE AND METHOD OF SEEDING SORGHUMS.

In the southern part of the sorghum region, where there is danger of injury to the grain by the sorghum midge, the crop should be seeded as early as climatic and soil conditions permit—usually early in March. If forage only is desired, however, seeding may be done at any favorable time up to July 15. Farther north the seeding should be delayed until May. In the latitude of Oklahoma and Kansas May 15 to June 1, on the average, is the best period for seeding. A safe rule in all localities except where the sorghum midge is troublesome is to seed about two weeks after corn-planting time. All sorghums are sensitive to cold soils and grow slowly until the soil becomes thoroughly warm. No advantage is gained, therefore, by seeding in a cold soil.

Perhaps 85 per cent of the sorghum acreage is planted in rows sufficiently far apart to permit cultivation with an ordinary corn cultivator. When the sorgos are grown exclusively for forage purposes other than silage many farmers prefer to sow them broadcast or drill them with a grain drill (fig. 3). This is a good practice, except in regions subject to drought or when in the growing of sorghums grain production is a feature to be considered. In such cases planting in rows is preferable. In general, there is very little difference in yield between the fields that are sown or drilled and those planted in widely spaced rows. The average yield of Red Amber and Sumac sorgos in tons per acre for a series of years at the Department field stations on the Great Plains is shown in Table I.

TABLE I.—*Average yields of leading varieties of sorgo at field stations of the United States Department of Agriculture on the Great Plains in recent years.*

Series of years.	Location.	Yield per acre (tons).	
		Rows.	Drilled.
1914 to 1918	Hays, Kans.[a]	3.15	3.62
1914 to 1917	Amarillo, Tex.	4.51	3.36
1914 to 1917	Chillicothe, Tex.[b]	4.93	4.50
Average		4.20	3.83

[a] All experiments at Hays, Kans., were conducted under a cooperative agreement with the Kansas Agricultural Experiment Station.

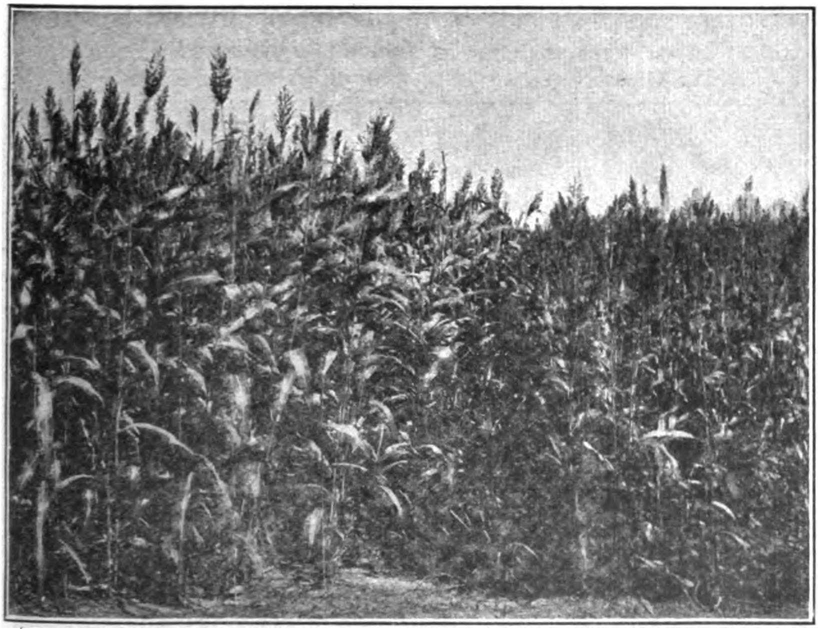
[b] All experiments at Chillicothe, Tex., were conducted under a cooperative agreement with the Texas Agricultural Experiment Station.

For planting in rows two general methods are followed—surface planting and listing, or planting in furrows. The first method is best suited to regions of moderate rainfall and the latter to dry sections.

Usually in surface planting sorghums the ground must be prepared by plowing and harrowing, after the practice followed in preparing ground for the seeding of a small grain crop (fig. 4). If, however, the soil is left clean and mellow by the preceding crop, it may be possible to prepare it by disking.

The ordinary corn planter, if provided with sorghum plates, will plant the seed satisfactorily. In order to distribute the seed evenly and prevent the plates from stopping up, the holes should be from three-sixteenths to one-fourth of an inch in diameter and reamed out on the lower side. The number of holes in the plate can be varied from 12 to 24 in order to give the desired stand; or the number of seeds dropped may be regulated by changing the speed with which the plate revolves (fig. 5). Very little sorghum is checkrowed, as it has been found better to distribute the seed evenly in the row rather than drop it in hills.

When using a lister, sorghum may be successfully planted on clean land without much, if any, previous preparation. Ordinarily, however, it pays at least to disk in the spring before listing. Experiments at Hays, Kans., have shown that it is profitable to fall list land, level the ridges when weeds start in early spring, and then list again at planting time.[7] Fall listing should be done at right angles to the prevailing winter and spring winds in order to catch snow and prevent the soil from drifting. The illustration on the title-page shows a field of Red Amber sorgo in shock in December, part of the field having been blank listed in preparation for the next season's crop.



3.—Red Amber sorgo drilled for hay. The plat on the left was sown at the rate of 15 pounds; that on the right, at 75 pounds to the acre.

Plates similar to those used in the surface planter are required for the lister. Sorghum planted with a lister usually starts growth more slowly in the spring, because the soil does not warm up so quickly at the bottom of the furrow. The roots are deeper in the soil, however, and a light rainfall, by collecting at the bottom of the furrow, becomes directly available to the small plants. Listed sorghum, though making a poor appearance in the early part of the season, is often more productive in the end than surface-planted sorghum.

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[7] Cunningham, C. C., and Kenney, Ralph. Growing sorghum in Kansas. Kans. Agr. Exp. Sta. Bul. 218, pp. 33-35. 1917.

Another advantage of the listed sorghum lies in the greater ease of keeping the weeds out of the row. The lister throws most of the weed seed out of the furrow, and by proper cultivation in the spring the weeds between the rows can be effectually destroyed in two cultivations. In surface-planted fields it is very difficult to remove the weeds in the rows without injuring the young sorghum plants, and four cultivations are often required to keep the crop clean. The western farmer who handles a large acreage is anxious to reduce the labor required, and this fact has induced many to use the lister in preference to the corn planter (fig. 6).

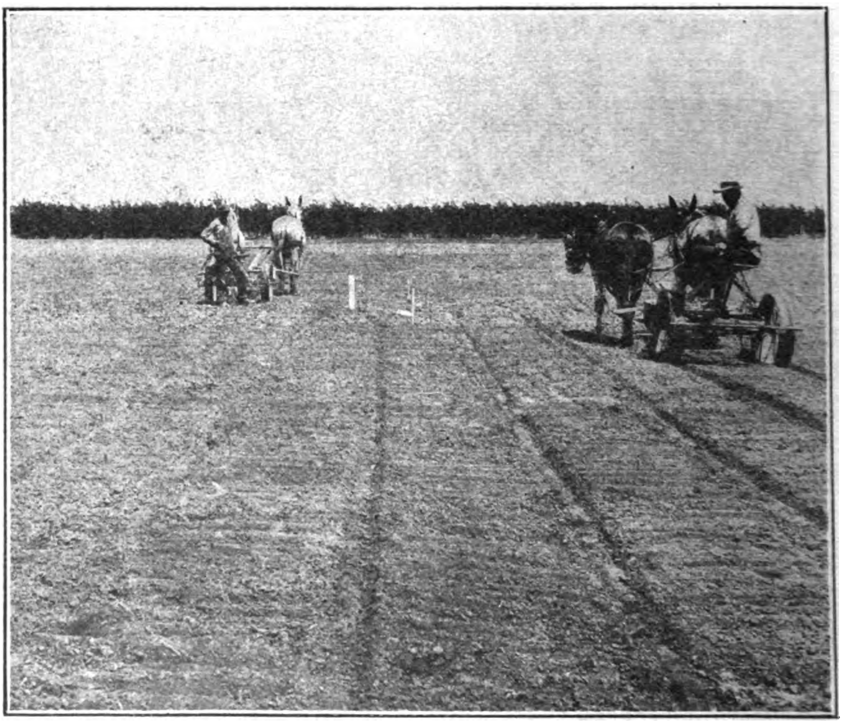

FIG. 4.—A field properly prepared for surface planting the sorghums.

An attachment to an ordinary corn planter which has been found especially useful in planting sorghum is the furrow opener. Two disks set just in front of the planter shoe open a shallow furrow, allowing the seed to be dropped in moist soil (fig. 7). This method of planting combines some of the advantages of listing by placing the seeds where they receive the full benefit of slight rains and in addition profit by the early warming of the soil in the spring. The prompt germination of the seed and the vigorous early growth of the plants are obtained by this method, which is gaining in favor with farmers in the eastern part of the district, where the lister has been so generally used.

The preparation of land for the seeding of sorghum broadcast or with a grain drill is practically the same as for surface planting in rows. The land should be harrowed thoroughly after plowing. If the plowing has been done early in the spring it is best to disk the land before seeding, to destroy the weeds which have started. This is highly important, because if the weeds are not destroyed they develop with the crop of sorghum and not only interfere with its growth but lower the quality of the hay obtained. Most farmers plow the land just before seeding in order to avoid this extra working of the soil.

The great advantages in drilled or broadcasted seedings over cultivated-row plantings lie in the fact that no cultivation is needed after seeding and that the hay produced is of finer quality; that is, finer stemmed. The greatest drawback to such seedings is the failure of the sorghum to mature in seasons of low rainfall. Sorghum which has not headed has not the feeding value of the fully matured plants. The crop is much more likely to head in cultivated rows than in drilled or broadcasted seedings.

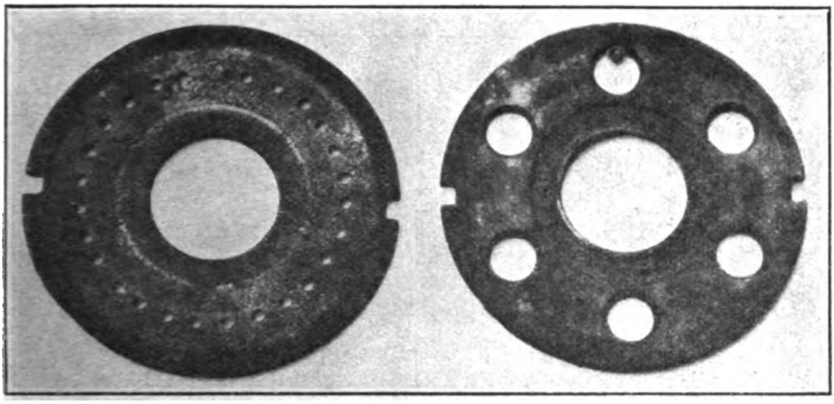

FIG. 5.—Plates used for planting sorghum and corn. On the left, a plate designed for planting kafir; on the right, one intended for dent corn.

RATE OF SEEDING SORGHUMS.

PLANTING IN CULTIVATED ROWS.

The rate of planting of sorghums in rows is of more importance from a grain than from a forage standpoint. Most of the sorghum varieties stool, or tiller, freely. When soil moisture is abundant and the stand is thin, each plant produces a large number of tillers, while if moisture is deficient the plant tillers less. This habit tends to equalize in a measure differences in the initial stand.

A large number of carefully conducted tests at agricultural experiment stations in the Great Plains have indicated that a slightly larger forage yield is obtained from fields where the distance between plants in the row is only 2 to 4 inches than from fields where the spaces between plants are greater. If every seed placed in the soil grew, 1 pound of seed of the Sumac variety or 1½ pounds of Amber sorghum to the acre would be sufficient to provide one plant for every 4 inches in rows 40 inches apart, but it has been found by experience that it is necessary for farmers to sow at least 3 to 4 pounds of seed to insure such a stand. In the drier parts of the sorghum region it is rarely, if ever, desirable to seed more than 4 pounds to the acre, and many prefer less. Farther east, where the rainfall is between 35 and 40 inches, it has been found preferable when growing the crop for fodder or silage to sow as much as 8 to 12 pounds per acre.

The average yield per acre of air-dry Red Amber fodder during a period of five years at Hays, Kans., when the plants were 2 inches apart in the rows, was 3.15 tons; 4 inches, 2.77 tons; 6 inches, 2.79 tons; 8 inches, 2.61 tons; 12 inches, 2.54 tons. At Amarillo, Tex., the average yield per acre of Sumac fodder during a period of four years was for plants 2 inches apart, 4.51 tons; 4 inches, 4.32 tons; 6 inches, 4.21 tons; 8 inches, 4.16 tons. With the grain sorghums no thicker rate than a 4-inch row space was tested. The general results, however, were the same as for the sweet sorghums. At Hays, Kans., the average yield per acre of feterita fodder during a period of four years was, for plants 4 inches apart, 2.59 tons; 8 inches, 2.43 tons; 12 inches, 2.33 tons; 16 inches, 2.17 tons; 24 inches, 1.86 tons. At Amarillo, Tex., the average yield per acre of Blackhull kafir fodder during a period of four years was for plants 4 to 6 inches apart, 3.08 tons; 8 to 10 inches, 2.75 tons; 12 to 16 inches, 2.51 tons. The fodder yields of Dwarf milo and feterita at Amarillo, Tex., for the same period varied in exactly the same ~~way as the yields of Blackhull kafir~~. At Chillicothe, Tex., the average yield per acre of Blackhull kafir

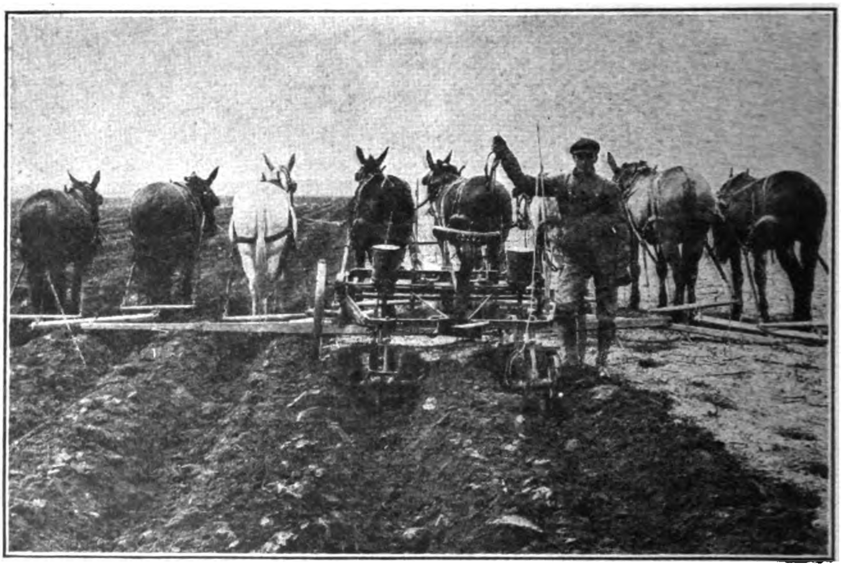

FIG. 6.—Planting kafir with a 2-row lister at the Fort Hays experiment station.

fodder during a period of 10 years was for plants 4 inches apart, 2.85 tons; 8 inches, 2.63 tons; 12 inches, 2.59 tons; 16 inches, 2.22 tons.

At all the experiment stations the highest fodder yield of both the sweet sorghums and grain sorghums was obtained from the thickest stand. The grain yield, however, was highest from the 8-inch spacing in most cases. Notwithstanding the higher yield of fodder from the thick rates, the fodder value was greatest in the intermediate rates. This was due to the more normal maturity of the plants and the greater proportion of grain in the thinner stands. On the basis of these results a 4-inch spacing is recommended for sweet sorghums and an 8-inch spacing for grain sorghums on the Great Plains.

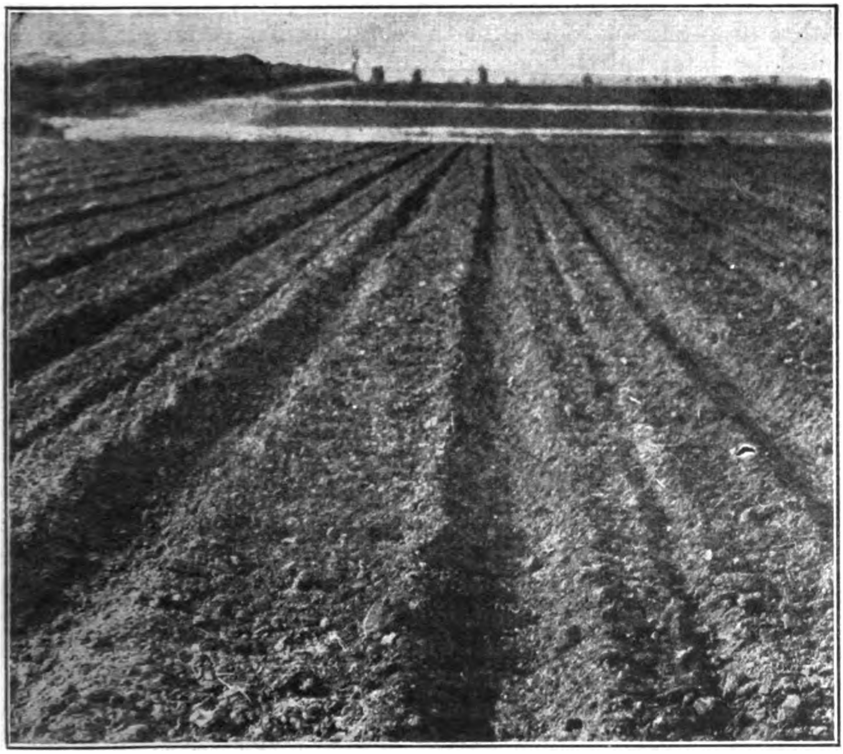

FIG. 7.—A field planted with a corn planter provided with a furrow-opening attachment. (Courtesy of the Kansas Agricultural Experiment Station.)

DRILLING OR BROADCASTING.

It has been the general practice among farmers to sow from 45 to 60 pounds of sorgo seed to the acre in drilled or broadcasted seedings. A 5-year test at one field station in Kansas and two in Texas have developed the fact that very little difference in yield is obtained whether one uses 15 pounds or higher rates up to 75 pounds of seed to the acre (see fig. 3). The 15-pound rate, however, gives a coarser growth, which is more likely to be infested with weeds, especially if the seed-bed conditions are not first class or the weather is not favorable for good germination of the seed and a vigorous early growth of the plants. It is recommended, therefore, on this basis west of the one hundredth meridian in the Great Plains to sow 30 pounds, between the ninety-eighth and one hundredth meridians 45 pounds, and east of the ninety-eighth meridian 60 to 75 pounds of seed to the acre.

CULTIVATION OF SORGHUMS.

The early growth of sorghum is slow, and the young plants therefore require care to prevent their being overcome by weeds. The first cultivation can be accomplished with an ordinary drag harrow, or, if the field is listed, with a disk weeder. Where the field has been plowed late in the spring and then surface planted, one cultivation with a drag harrow soon after the sorghum has emerged, to be followed by later cultivations with an ordinary shovel cultivator, is most efficient. Sorghum when surface planted grows faster than when planted with a lister, so that there is less immediate danger of weeds getting ahead of the crop.

In listed plantings, after the harrow has been utilized for the first cultivation, a cultivator with knives on each side designed to cut under the weeds is especially efficient in killing those on the edge of the furrow. A homemade cultivator of this sort, often called by the western farmer a "go-devil," is made by attaching heavy steel blades 30 to 40 inches long to a narrow sled, the runners of which are 2 by 10 planks at least 5 feet long and only 8 to 10 inches apart. To each side of the sled is bolted one of these blades, so that it extends backward at an angle of about 45°. These blades should be 4 or 5 inches wide and sharpened along the entire front edge. Attached in directly opposite positions, they have a spread of approximately 4 feet 6 inches. When the sled is running in the furrow the knives cut through the ridges on each side a little beyond the center, thus entirely freeing these spaces of weeds. If the knives are set at the proper angle they will maintain a fairly constant depth and free themselves of roots and trash, with the operator riding on the sled. When well made this sled cultivator is very efficient.

Manufactured knife cultivators are on the market, as well as disk cultivators designed especially for listed crops. (Figs. 8 and 9.) Some of these handle two rows at a time and are reasonably efficient, but none of the trade cultivators is more effective in killing weeds than a good homemade sled cultivator. After the sorghum is 10 or 12 inches high a shovel cultivator can be used. Late cultivations should be shallow, in order to avoid breaking the feeding roots.

THE TIME TO HARVEST SORGHUMS.

Sorghum should be fairly mature before being cut for forage. There are several reasons for this: The largest tonnage of dry matter is obtained from mature sorghums, the feed is more palatable, the danger from prussic-acid poisoning is less, the fodder does not sour in the shock so easily, there is a smaller shrinkage in weight during the curing, and the silage made from mature sorghum contains less acid and does not spoil when properly ensiled.

The best time to cut sorghum for fodder is when the seeds have reached the hard-dough stage. Cut at this time, the sap in the stem is sufficient to complete the development of the seed after the fodder is shocked. Drilled or broadcasted sorghum should also be allowed to form seed before it is harvested, unless dry weather interferes with its full development and threatens to ruin the crop. Experiments in which cuttings were made at different stages of maturity show not only that the largest quantity of cured forage is obtained when the crop is harvested after the seeds are well formed, but also the highest acre yield of protein, carbohydrates, and fat.

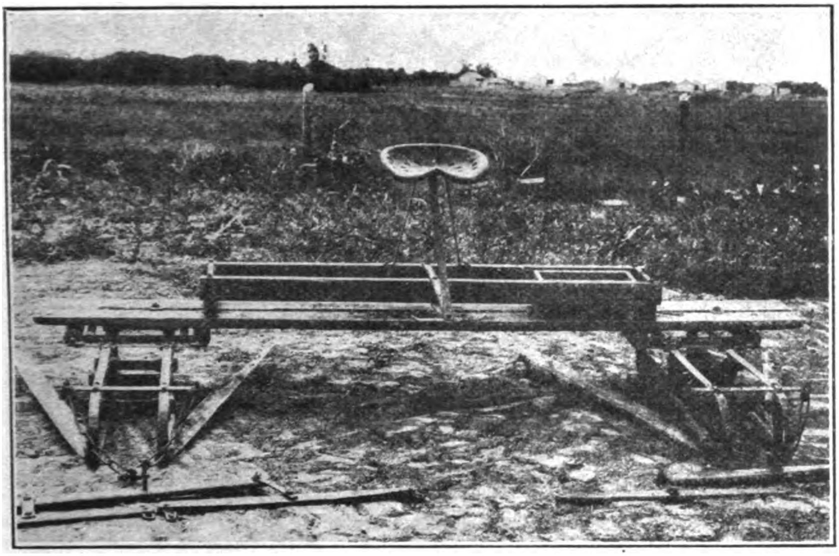

FIG. 8.—A knife cultivator now on the market which is constructed on the same principle as the home-made sled cultivator except that it cleans two rows at one trip.

METHODS OF HARVESTING THE SORGHUMS FOR FODDER, SILAGE, AND HAY.

When labor was cheap the almost universal method of harvesting sorghum grown in rows was to cut the standing plants near the ground with corn knives and place them in shocks to cure. If the grain only was desired, the heads were cut and thrown directly into a wagon box. This method is widely used to-day by farmers who grow only a small acreage of sorghum or who are not supplied with labor-saving farm machinery.

The increasing cost of farm labor has made it necessary to substitute machines for laborers wherever practicable. The most efficient machine for harvesting sorghum as fodder is a row binder (fig. 10), with which a farmer assisted by one man to set up the bundles in shocks can take care of a considerable acreage of sorghum. When once carefully shocked, sorghum keeps in good condition until late in the winter and can be hauled to the barnyard to be fed or stacked whenever other work is not pressing. (See the illustration on the title-page.)

When the crop is intended for silage a row binder should be used. The bundles tied securely are much easier to haul to the silo than loose stalks cut with a corn knife.

Broadcasted or drilled sorgo is usually harvested as a hay crop with a mower and rake. In dry climates farmers often harvest "sowed cane" with a binder, but unless very dry weather prevails it may spoil in the bundle. Care must be observed in curing sorgo when it has been cut with a mower, as the stems are very juicy, and it takes a long time to cure sufficiently to be ready for the stack. It is best to allow the crop to lie in the swath for a day or two, then rake into windrows and leave at least four days, or longer if the weather is not favorable for curing. As soon as the leaves are fairly dry the hay may be placed in cocks to complete the curing process.

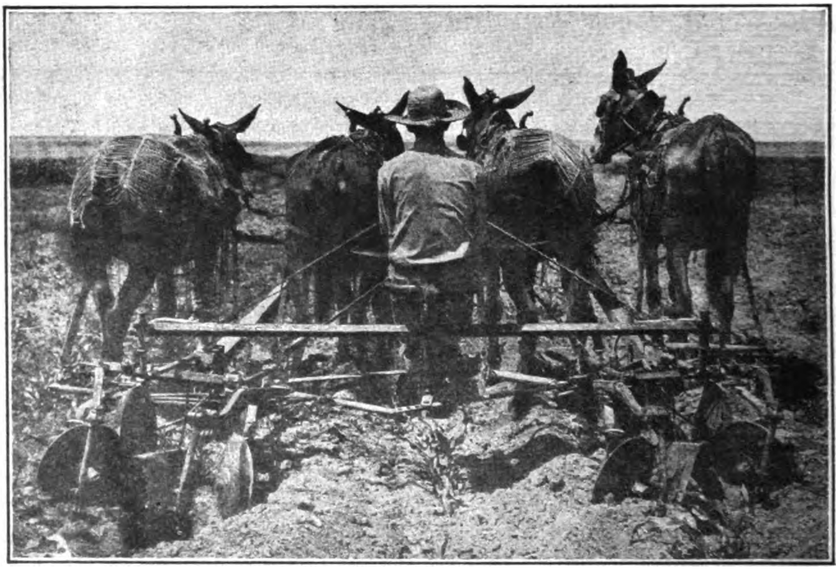

FIG. 9.—A combined disk and shovel 2-row cultivator that is much used in the West for cultivating listed sorghum and corn.

THE PRODUCTION AND VALUE OF GOOD SORGHUM SEED.

For his own seeding the farmer should use heads selected in the field before frost. This seed, even though slightly immature, will germinate well if the heads are thoroughly cured by hanging them upon wires in the barn loft or granary. The practice of curing ears of seed corn in this way is common among corn growers and has resulted in a decided improvement in the crop. All sorghums cross-pollinate freely in the field. The sweet sorghums are more often mixed as to variety than the grain sorghums, because the seed crop is secondary in importance to the fodder. A special effort is therefore necessary to produce pure seed. Where a field is intended for seed production it should be rogued carefully; otherwise the presence of stray plants of other varieties will result in endless hybridization. This intermixing of varieties results in a lack of uniformity in ripening as well as in the size of the plants, thus causing difficulty in harvesting and loss in marketing the crop.

Sweet-sorghum, or "cane," seed is harvested in the same way as the seed of grain sorghums. The most economical method is to use a grain header, but much of it is still gathered by hand from standing stalks in the field or after the crop has been cut with a row binder and shocked. (Fig. 11.) Considerable extra money may be realized by farmers in the sorghum belt if they will save the seed from their sorghum fodder. This is particularly true when standard sorgo varieties, such as Black Amber, Red Amber, Orange, Honey, and Gooseneck, are grown.

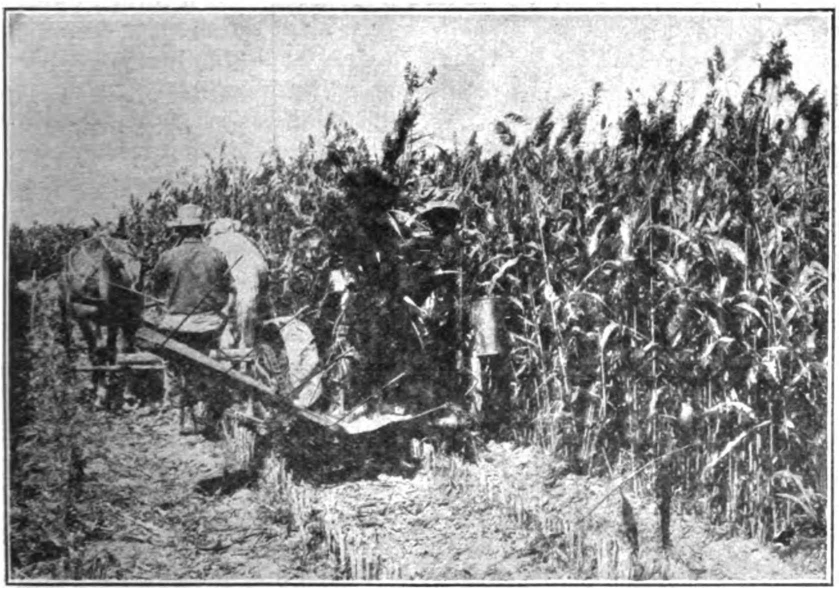

FIG. 10.—Cutting Red Amber sorgo with a row binder. This shows the best way of harvesting row sorghums for fodder and silage.

Large quantities of the harvested heads thrown together in a crib or bin are likely to heat and lose their germinating power. In dry climates they may be piled in narrow ricks in the open, but it is better to place these ricks under cover. Seed intended for feeding purposes is not injured much by a little moisture, but wet seed and immature seed are rendered almost worthless for planting if freezing temperatures occur.

Neighbors may work together very effectively in thrashing sorghum seed, the heads being hauled to some designated central point. An ordinary grain separator can be used effectively for thrashing if properly adjusted. To avoid cracking the seed it is best to remove all but two or three rows of concave teeth and reduce the speed of the cylinder to about two-thirds that used in thrashing wheat. The distance between the cylinder and the concaves should be increased when thrashing soft-grained sorghums, like feterita, and lessened for the sweet sorghums, which are harder to thrash.

THE VALUE OF SORGHUM-LEGUME MIXTURES.

The practice of seeding mixtures of sorghum and cowpeas or of sorghum and some other legume, such as soy beans or velvet beans, when forage alone is desired, is commendable in theory, but in actual practice it has not been a complete success. On the Great Plains, where the rainfall is deficient, the sorghums make a more vigorous growth than cowpeas or soy beans and usually crowd out the legumes. In the humid regions such mixtures are more successfully grown, but the difficulty of harvesting the mixed crop prevents its extensive use. The growing of any mixture of this kind should be attempted only in localities where both the sorghum and legume are well adapted to climatic and soil conditions.

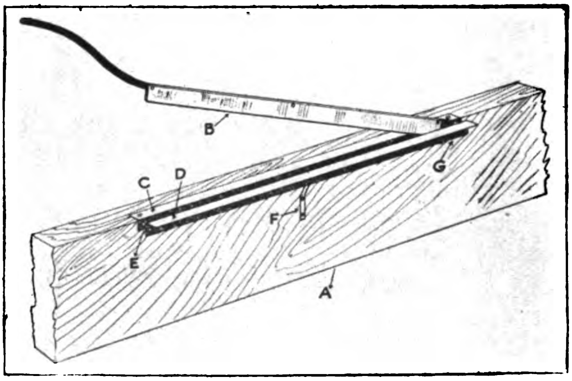

FIG. 11.—A contrivance for cutting the heads from bundles of sorghum: *A*, Plank 2 by 8 inches by 10 feet long which can be bolted to the side of a header box or wagon box; *B*, a stout knife 24 to 28 inches long hinged on the bolt *G*; *C* and *D*, angle irons fastened to the top of the plank half an inch apart. *C* is fastened with lag screws and *D* with bolts *E* and *G*, passing through the plank and with the brace *F*.

THE UTILIZATION OF FORAGE SORGHUMS.

USE AS A HAY CROP.

In the United States south of latitude 37° and east of longitude 105° sorghum hay is quite widely used on the farms to feed work mules and, to a lesser extent, other farm animals. Though somewhat laxative, it is nutritious, and work animals maintain their vigor when fed on it even though their grain ration is light.

When grown for hay, sorghum is usually broadcasted or drilled. In the region just mentioned it is often sown as a catch crop, occupying land which otherwise would lie idle. A small part of the hay is marketed loose near by, but sorghum is not especially desirable as a market hay, because it is rather coarse and difficult to cure sufficiently well to stand baling. Sorghum is extremely valuable in the Southern States, however, on account of the certainty of producing a crop. No other hay grasses have been found equal to it in this respect except Johnson grass and Sudan grass. Both of these make smaller yields, and Johnson grass becomes a weed on fertile soils.

USE AS FODDER.

A large percentage of the sorghum used for forage purposes is cut and fed as fodder; that is, the whole plant with the head or grain attached is cured and fed without removing the grain. Nearly all the sweet sorghum grown in cultivated rows and about 40 per cent of the grain-sorghum acreage are handled in this way. The sweet sorghums produce on the average about 1 ton per acre more fodder than the grain sorghums, and live stock of all kinds eat the stems more readily on account of their sweetness.

A long period for curing in the shock is necessary to the production of good sorghum fodder. In regions where the rainfall is light little injury is sustained by the fodder in standing out through the winter, and most of it is fed from the shock instead of being stacked. Some difficulty is experienced in certain sections with sorghum souring in the shock. This trouble usually arises from cutting the sorghum while it is immature.

Well-cured fully matured sorghum fodder will maintain live stock in good condition through the winter with little or no supplementary grain ration. Chemical analyses indicate that the food value of sorghum fodder is practically the same as that of corn fodder, and it is much more palatable; hence can be fed with less waste. The high value of kafir fodder in wintering cattle and work animals has been fully demonstrated by feeding tests at the Fort Hays experiment station, Hays, Kans.

The feeding of shredded sorghum fodder, mixed with corn chop, bran, cottonseed meal, or other concentrates, has given good results with dairy cows, and during the heavy feeding periods with beef cattle. Shredding the fodder before feeding decreases the waste, but unless the feeding operations are conducted on a large scale and the equipment includes a powerful engine, the practice of shredding fodder is not often profitable.

USE AS A SOILING CROP.

Sorghum can be used as a soiling crop provided care is observed to avoid bloating and prussic-acid poisoning. The crop becomes available during the period of summer drought when pasture and other feeds are scarce. It can be cut from the time it is 2 to 3 feet high until it ripens, but the early cuttings have inferior feeding value and are more likely to contain dangerous quantities of prussic acid.

Unless feed is badly needed, therefore, it is best to delay cutting until the plants have headed.

Successive seedings must be made or several varieties of different degrees of earliness used, in order to extend the soiling season over a considerable period. A second growth starts promptly from the stubble, especially when the plants have been cut before maturity. The yield of soilage from sorghums is larger than from almost any other crop. Yields of 12 to 15 tons per acre may be expected on fairly fertile soils. (Fig. 12.) The crop can be grown for soiling purposes either in cultivated rows or in close drills. Harvesting is a comparatively simple matter, the drilled sorghum being handled with a mower and rake and that in rows with a row binder or corn knife.

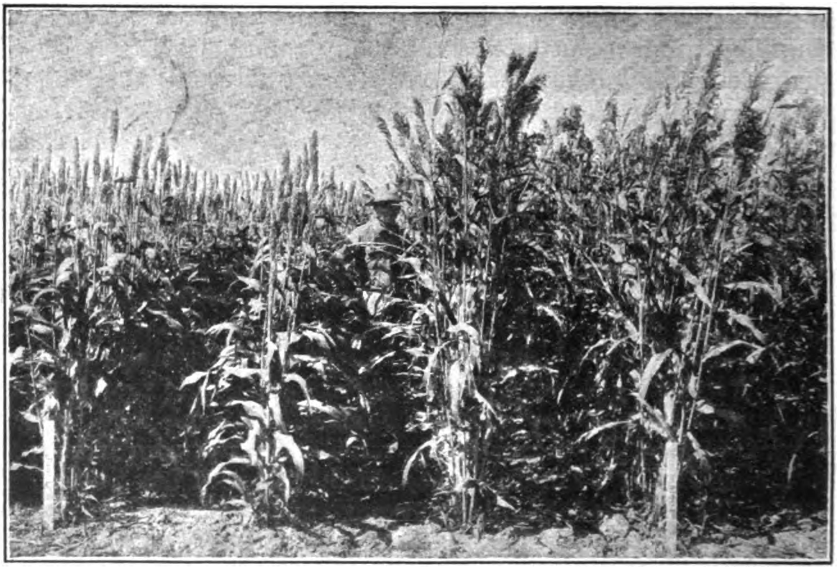

FIG. 12.—Red Amber sorgo and Blackhull kafir grown for silage at the Fort Hays experiment station, Hays, Kans. Blackhull kafir on the left, Red Amber sorgo on the right. Planted June 1; photographed September 6. Yields per acre: Blackhull kafir, 15.73 tons; Red Amber sorgo, 17.33 tons.

USE AS SILAGE.

Until recent years sorghum was not valued highly as a silage crop. This was largely because farmers did not understand the necessity of allowing the crop to ripen before it was cut. Silage made from immature sorghum is sour and does not keep well. When the sorghum is not cut until the seeds are hard the silage has less acid than corn silage and keeps fully as well. (Fig. 13.)

The average acidity for the different kinds of silage, as determined by the Kansas Agricultural Experiment Station in 1913, was as follows: Corn, 2.03 per cent; sorgo, 1.46 per cent; kafir, 1.43 per cent.[8]

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[8] Reed, O. E., and Fitch, J. B. Sorghum crops for silage. Kans. Agr. Exp. Sta. Circ. 28, 6 p. 1913.

By a series of experiments which fully demonstrate the value of sorghum silage the Kansas Agricultural Experiment Station has done much to overcome the early prejudices. Silage made from kafir was found equal to corn silage whether fed to beef cattle or to dairy cows. Sweet-sorghum silage was 3 per cent less valuable than corn silage, pound for pound, when measured by the milk produced,[9] but when fed to beef cattle it was fully equal to corn silage.

Corn, kafir, and sorgo silages were compared in feeding experiments with beef calves conducted by Prof. W. A. Cochel at the Kansas station during a period of three winters. A ration consisting of corn silage, wheat straw, and cottonseed meal produced an average daily gain of 1.19 pounds at a cost of 5.26 cents per pound of gain. Kafir silage substituted for the corn silage resulted in a daily gain of 1.28 pounds at a cost of 4.88 cents per pound, and sorgo silage substituted for corn silage resulted in a daily gain of 1.12 pounds at a cost of 5 cents per pound. The average daily ration was 27 pounds of silage, 1 pound of cottonseed meal, and, in addition, all the wheat straw the animal would eat.

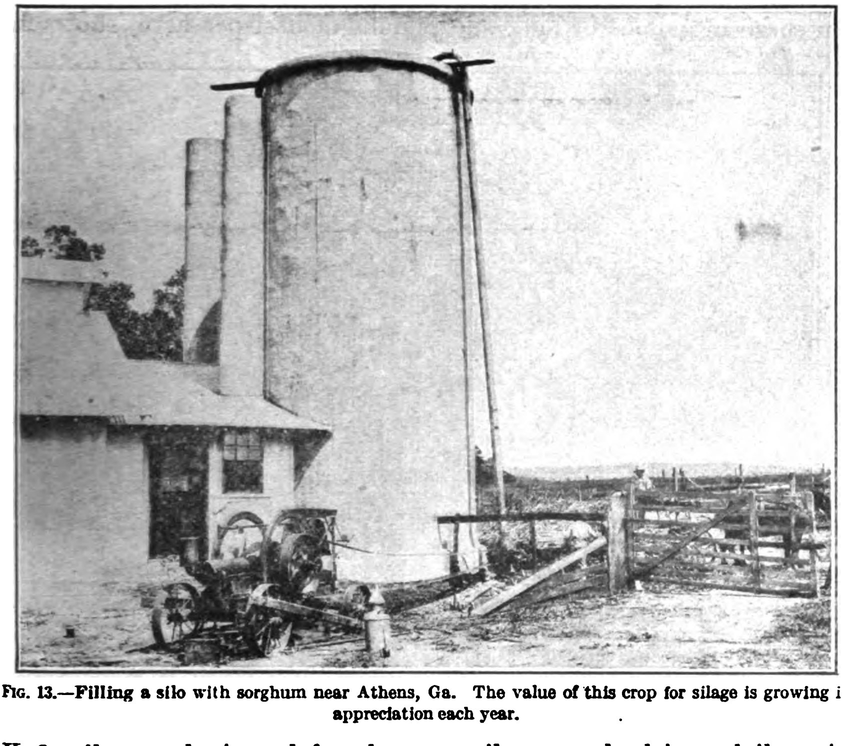

FIG. 13.—Filling a silo with sorghum near Athens, Ga. The value of this crop for silage is growing in appreciation each year.

The striking advantage of sorghum silage over fodder in a ration for wintering live stock was shown at the Fort Hays Branch Experiment Station in 1912–13. A ration of 27 pounds of kafir fodder, 10 pounds of wheat straw, and 1 pound of cottonseed meal fed to breeding cows resulted in a daily gain of only 0.5 pound and cost 19.82 cents per pound of gain. A daily ration of 35 pounds of kafir silage, 14 pounds of wheat straw, and 1 pound of cottonseed meal resulted in a daily gain of 1.34 pounds at a cost of 4.7 cents per pound. Experiments at the same station in the winter of 1918–19 indicated that 1 acre of kafir fed to cows as silage was equal to 1.78 acres fed as fodder.

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[9] Reid, O. E., and Fitch, J. B. Op. cit.

The silage yield of sorgo, especially in the Great Plains area, is consistently larger than that of kafir or corn. (Figs. 12 and 14.) The results obtained, therefore, when figured on the basis of pounds of beef or gallons of milk per acre, are very favorable to sorgo. This is illustrated graphically in figure 15, which compares sorgo, corn, and kafir when grown on fertile soil in the eastern part of the State.

The diagram (fig. 15), giving as it does the potential acre value of sorgo in gallons of milk and pounds of beef per acre, shows in a striking manner the high value of this crop when it is utilized as silage. There is little doubt that some, though not all, of this superiority over corn is lost in the succeeding crop, since most investigators admit that corn leaves the field in better condition for wheat or other small grains than does sorghum.

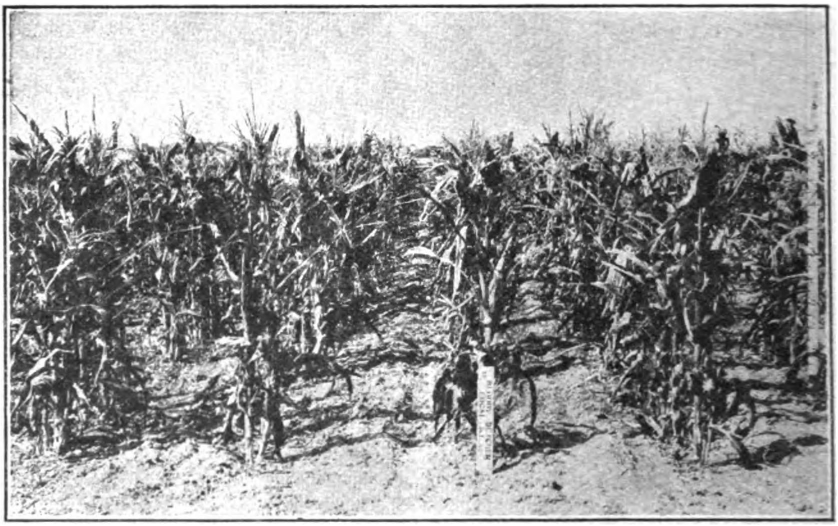

Fig. 14.—Bloody Butcher corn at Hays, Kans., August 27, 1919, showing the behavior of corn on the uplands of western Kansas in average years.

The higher yielding power of sorghum for silage is shown in nearly all tests reported. At the Kentucky Agricultural Experiment Station the average yield per acre of corn silage for a 5-year period from 1915 to 1919, inclusive, was 10.7 tons, as against a yield of 17 tons for sorghum silage. At the Tennessee Agricultural Experiment Station corn averaged 7.4 tons, sorghum 14.2 tons, and corn and sorghum mixed 10.4 tons per acre. At the Michigan Agricultural Experiment Station corn made 14.8 tons and sorghum 19.3 tons of silage per acre.

A feeding experiment was carried out at the Kentucky Agricultural Experiment Station in 1918–19, comparing corn silage with sorghum silage. The steers fed corn silage made a daily gain of 2.15 pounds per head. Those fed sorghum silage averaged 1.95 pounds of gain per head daily, notwithstanding that one steer in the sorghum lot was off feed for nine days. A net profit of approximately $20 per steer was realized in both lots with the silage valued at $8 per ton, which value gave a gross return of $78.32 per acre for the cornfield and $136 per acre for the sorghum field.

Stockmen on the Plains lose large numbers of cattle in hard winters through starvation and freezing. This loss could be almost entirely prevented by the use of reserve feed stored in pit silos, like those shown in figure 16. These silos are inexpensive to construct and in no danger of destruction by the wind. In favorable seasons such silos can be easily filled with sorghum, thus holding a surplus of cheap feed in reserve against the time of need. Properly made, silage keeps almost indefinitely in a pit silo. Silage-fed cattle that have access to straw piles come through the winter in good condition instead of losing most or all of the gains made during the summer grazing period.

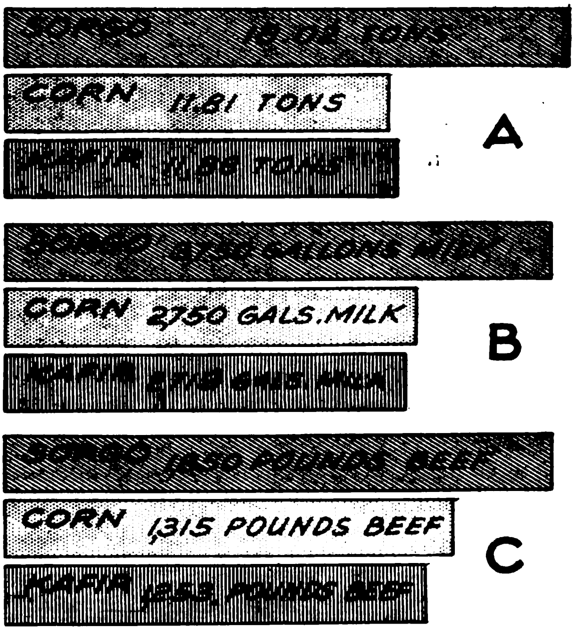

FIG. 15.—Comparison of sorgo, corn, and kafir for silage on rich soil at Manhattan, Kans.: *A*, Average yield per acre for the 5-year period from 1912 to 1916, inclusive (Cunningham, C. C., and Kenney, Ralph. Kans. Exp. Sta. Bul. 218, p. 11, 1917). *B*, Yield of milk obtained from 1 acre of silage when fed to dairy cows in a ration with a small quantity of alfalfa hay and grain (correspondence with J. B. Fitch, August 22, 1919). *C*, Beef obtained from 1 acre of silage when fed to calves in a ration with 1 pound of cottonseed meal.

Farmers who keep a few milk cows also find a supply of silage very profitable. Care should be used in planning the diameter of the silo, so that at least 2 inches of the silage will be fed each day after the silo is opened. If the silo is so large that less than this quantity is required for the stock, the ensilage will spoil on top.

USE AS PASTURE.

Sorghum has been recommended as a summer pasture for live stock of all kinds, but there is more or less conflict of opinion regarding its value for this purpose. The general result of well-planned experiments is to discourage its use as pasture both for hogs and cattle. Most of the successes with sorghum as pasture have resulted from the turning in of milk cows on a nearly mature crop.

The danger of prussic-acid poisoning has tended to prevent farmers from pasturing sorghums very extensively, except with hogs. There seems little danger to hogs from the poison, but cattle are particularly susceptible; therefore the sorghum should invariably be tested for poison by turning some animal of little value into the field first. If the poison is present in dangerous proportion the fact will become apparent in a few minutes.

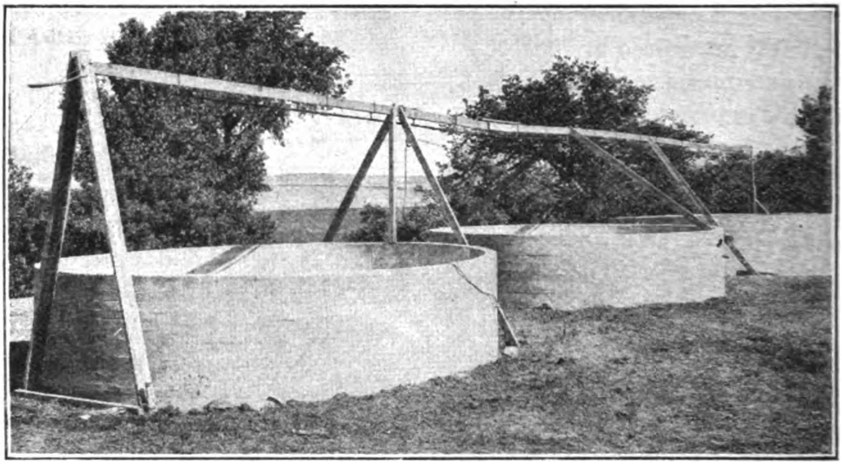

FIG. 16.—Battery of pit silos on a ranch between Hays and Plainville, Kans. These silos are 20 feet in diameter and 25 feet deep.

SORGHUM SEED AS A GRAIN RATION.

The utilization of the seed of grain sorghums as a grain ration for farm animals is increasing rapidly. These grains are especially valuable for use in chicken feeds, but can also be fed with good results to cattle, horses, sheep, and hogs. The general belief among feeders is that the sorghum grains are worth about 90 per cent as much as corn when measured by gains in flesh. This is true, however, only of kafir, milo, feterita, and other grain sorghums. Sorgo seed is less valuable because the seeds of nearly all sweet-sorghum varieties contain an appreciable amount of tannin. This tannin has an astringent effect on the digestive processes, evidently thereby lowering the feeding value of the grain.

The relative value of sorgo seed as compared with corn and seed of the grain sorghums is brought out in Bulletin 192 of the Kansas Agricultural Experiment Station.[10] In a feeding test with hogs covering a period of 80 days, a lot fed ground sorgo seed and alfalfa hay made an average daily gain of only 0.88 pound. Those given ground milo in place of the sorgo seed averaged 1.2 pounds per day; those fed ground kafir, 1.3 pounds per day; and those given ground corn, 1.5 pounds per day. Where the ration was only 62 per cent corn or sorghum seed, 30 per cent shorts, and 8 per cent tankage, the gains were more nearly equal from the different grains.

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[10] Wheeler, G. C. Hog feeding. Kans. Agr. Exp. Sta. Bul. 192, p. 353–426, 8 fig. 1913.

Additional information on the value of grain-sorghum seed as a substitute for corn in feeding live stock is to be found in Farmers' Bulletins 724 and 972 of the United States Department of Agriculture, entitled, respectively, "The Feeding of Grain Sorghums to Live Stock" and "How to Use Sorghum Grain."

CHEMICAL COMPOSITION AND DIGESTIBILITY OF SORGHUM FORAGE.

In composition and digestibility, sorghum fodder and sorghum silage are very similar to corn fodder and corn silage. This fact is indicated in Table II, compiled from Henry and Morrison's Feeds and Feeding, sixteenth edition.

TABLE II.—*Average composition of corn, kafir, and sorgo forage.*

Crop.	Number of analyses.	Constituents (per cent).					
		Water.	Ash.	Crude protein.	Fiber.	Nitrogen-free extract.	Fat.
Field-cured fodder:							
Corn	23	39.3	3.6	4.8	16.7	34.2	1.4
Kafir	20	40.0	6.2	5.9	17.7	28.4	1.8
Sorgo	11	37.4	3.1	3.9	17.8	35.0	2.8
Silage from fairly mature plants:							
Corn	121	73.7	1.7	2.1	6.3	15.4	.8
Kafir	3	69.2	2.5	1.8	9.9	15.5	1.1
Sorgo	30	77.2	1.6	1.5	6.9	11.9	.9

According to the above authority, corn, both as fodder and as silage, is slightly more digestible than kafir or sorgo. In fodder, the percentage of digestibility for the dry matter of corn is 66, kafir 59, and sorgo 58. In silage the percentage of digestibility for the dry matter of corn is 66, kafir 55, and sorgo 57.

PRUSSIC-ACID POISONING.

A serious disadvantage in the use of sorghum as a pasture or soiling crop is the danger of prussic-acid poisoning. Almost every farmer who has grown sorghum as a farm crop knows that it is dangerous to allow cattle to eat even a small quantity of green sorghum before it has matured. The wild animals of Africa are said to avoid sorghum instinctively while it is young, refusing to eat it until it has ripened. However this may be, domestic animals in America show no such intuition, and a considerable loss of cattle is sustained each year in the United States from sorghum poisoning.

No sure remedy for prussic (hydrocyanic) acid poisoning has yet been found. Doses of glucose (corn sirup) or large quantities of milk will prove beneficial if the animal is not too nearly dead.[11] A remedy advocated by a correspondent and published only as a suggestion, since the Department of Agriculture has no proof of its efficacy, is as follows: A half teaspoonful of soda is added to a half pint of dilute vinegar and given to the animal while the mixture is still foaming. This dose is repeated at intervals until the animal is relieved. It is claimed that cattle have been saved by this treatment, even after they were down.

There are certain points regarding sorghum poisoning which have been fairly well established, and these should be kept in mind by every sorghum grower:

(1) Sorghum is most dangerous when its normal growth has been interrupted by an acute drought or by frost.

(2) The prussic-acid content of sorghum decreases as the plant approaches maturity. Mature plants with ripe seeds are seldom dangerous, especially if the growth has been normal.

(3) The slow curing of sorghum releases three-fourths of the prussic acid and ordinarily makes the cured fodder safe to feed animals. Rapid drying releases less of the acid and is therefore a less effective safeguard.[12]

(4) Sorghum silage can be fed with safety.

(5) Loss usually comes from pasturing cattle on sorghum. This should never be attempted without first testing the field with an animal of little value. Even if the sorghum appears safe to pasture after such a test, the herd should not be turned in the field with empty stomachs. A light feed of grain given prior to turning the animals on the sorghum will do much to prevent injury.

(6) Less trouble is experienced in the Southern States than in those farther north.

DISEASES OF SORGHUMS.

RED-SPOT.

The red-spot, formerly known as "sorghum blight," is perhaps the most troublesome of all sorghum diseases from a forage standpoint. It affects both the stem and leaves of the plant, manifesting itself in red or purple spots, which at first are more or less circular, but which spread most rapidly lengthwise of the stem or leaf, becoming oblong or rectangular splotches (fig. 17). When these discolored areas become very numerous the leaves cease to function and the growth of the plant stops.

Red-spot is most destructive in warm, humid climates like that of the Gulf coast. It is always to be found on the Great Plains, but does little damage except in wet seasons. Some varieties are more susceptible to it than others. Sudan grass is of little value in Florida and other parts of the Gulf coast because of its susceptibility to this disease.

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[11] Peters, A. T., Slade, H. B., and Avery, Samuel. Poisoning of cattle by common sorghum and kafir corn. Nebr. Agr. Exp. Sta. Bul. 77, 16 p. 1903.

[12] Dowell, C. T. Cyanogenesis in Andropogon sorghum. *In* Jour. Agr. Research, v. 16, no. 7, p. 179. 1919.

No remedy or preventive of the red-spot has yet been found other than the growing of resistant varieties. In localities where it is especially destructive, as along the Gulf coast, Japanese cane or Napier grass should be grown instead of the sorghums.

KERNEL SMUT.

The kernel smut of sorghums is most important, of course, from the standpoint of grain production. All the principal groups of sorghums except milo and feterita are subject to kernel smut, and the losses in some districts are quite severe.

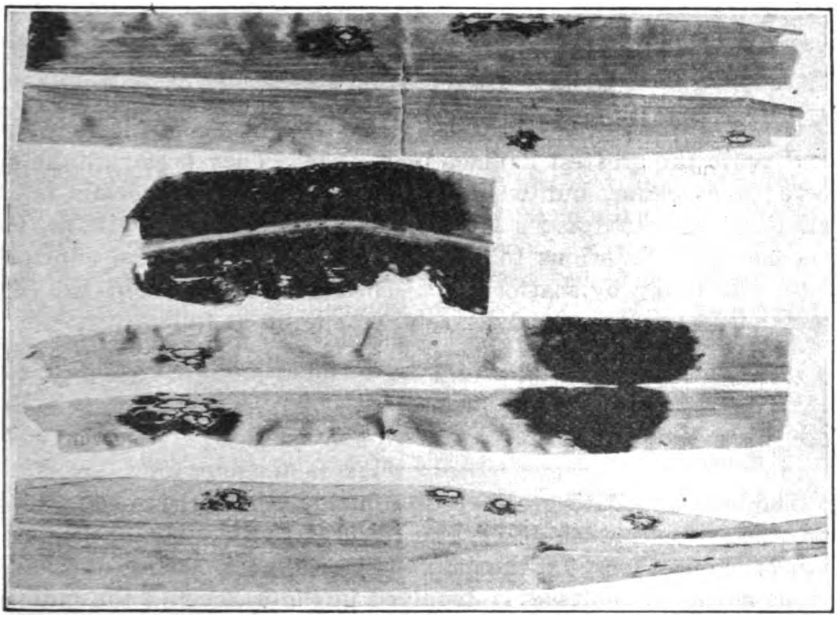

FIG. 17.—Leaves of one of the sweet sorghums affected by red-spot, or sorghum blight. Note the characteristic small red spots on the two outer leaves. The larger areas on the center leaves show how these spots spread over the leaf in the later stages.

In the kernel smut the individual grains or kernels in the head are attacked and changed into a mass of dark-colored spores. The head itself retains its shape and these spore masses look somewhat like elongated seeds. Unlike the red-spot, kernel smut can be controlled by seed treatment. The formaldehyde treatment is probably the most effective.[13] One pound of 37 per cent formaldehyde solution is mixed with 30 gallons of water. The sacks of seed are immersed for one hour in this solution, which should be stirred occasionally. Then the sacks are taken out and drained, after which the seed is spread upon a clean floor or canvas to dry. When dry the seed may be sown, but care must be taken to see that it does not come in contact with any infected sacks after the treatment.

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[13] Humphrey, H. B., and Potter, A. A. Cereal smuts and the disinfection of seed grain. U. S. Dept. Agr., Farmers' Bul. 939, 28 p., 16 figs. 1918.

HEAD SMUT.

The disease known as head smut is much less common than the kernel smut. The whole head when it emerges from the upper leaf is a mass of dark-colored spores mingled with the fibrous remnants of the host tissue and inclosed within a grayish membrane. This membrane soon ruptures and permits the escape of the spores.

Head smut can not be controlled by seed treatment, largely because soil infestation is known to occur. The only safe plan is to avoid the use of seed from localities where it is known to occur and to cut out and burn all plants affected with it before the spores ripen.

INSECT ENEMIES.[14]

GRASSHOPPERS.

Grasshoppers are troublesome principally in the semiarid regions and cause the greatest damage in Kansas. They prefer alfalfa and corn to sorghum, but when they become very numerous or the alfalfa is harvested and a field of corn is not readily available, they become quite injurious to the sorghums. They can be controlled most effectively by scattering poisoned bran mash about the edges of the field. This poisoned mash is made up as follows:

Bran	pounds	25
Paris green or white arsenic	do	1
Molasses	quarts	2
Oranges or lemons		3
Water	gallons	3 to 4

The bran and Paris green are thoroughly mixed dry in some receptacle, such as a wash tub. The juice of the oranges or lemons is squeezed into the water, the pulp and peeling chopped fine and added, after which the molasses is dissolved in the water and the poisoned bran is moistened with this solution. Ordinary table sirup is not as effective as a strong-smelling molasses.

Where the grasshoppers are troublesome it is best to scatter this damp mash about the field early in the morning, about the time they are beginning to move about. The quantity described in the foregoing formula should be sufficient for 4 to 5 acres.

CHINCH BUG.

None of the better varieties of forage sorghums are liable to be injured very extensively by chinch bugs unless the infestation occurs when the plants are small. So long as favorable growing conditions prevail, the damage will be slight in all cases except in milo, which is much more susceptible to injury than any other well-known variety.

A field of sorghum can be protected from chinch-bug invasion by means of a deep furrow plowed around the edges of the field, running the land side of the plow toward the field. In dry weather the sides of the furrow thus made can be rendered so steep and the earth so evenly pulverized that the chinch bugs can not crawl out of it. In showery weather the bottom of the furrow can be smoothed with a shovel, thus making it easier for the bugs to follow along the bottom than to climb the sides of the ditch. If holes with perpendicular sides are then dug across the bottom of the ditch at intervals of 30 to 40 feet, the chinch bugs will fall into them, and can be disposed of easily by the application of kerosene oil. The bugs commonly pass the winter at the base of bunches of grass and in the piles of trash usually found along fences and hedgerows. Burning this grass and trash in November or December destroys a large percentage of the chinch bugs and does much to prevent trouble with them the following summer.[15]

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[14] Prepared with the advice and cooperation of W. R. Walton, Entomologist in Charge of Cereal and Forage Insect Investigations, Bureau of Entomology, United States Department of Agriculture.

ANTS.

Ants do considerable damage to newly planted fields of sorghum by eating out the kernel and thus preventing germination. The ants that do this are small and reddish in color. The only practicable way to control them is to prepare the seed bed carefully and plant when the ground is in good condition, so that the seed will germinate promptly. Frequent cultivations help materially in breaking up the ant colonies and thus reducing general injury to the crop.

SORGHUM MIDGE.

The sorghum midge is abundant in the Southern States from central Texas east. In that region it usually prevents the production of sorghum seed to such an extent that the growing of grain sorghum is unprofitable. A complete description of the sorghum midge, suggesting methods of control, has been published in United States Bureau of Entomology Bulletin 85.[16]

The sorghum midge is a very small fly with a red body which lays its eggs within the hulls or glumes of the sorghum flower before blossoming time. The egg produces a small white larva, or grub, which takes its position alongside the developing ovary and absorbs the juices, thus preventing the development of the seed. This larva soon attains its growth and changes into a pupa, from which the adult fly, or midge, emerges in a few days and starts a new generation by depositing eggs on other sorghum heads. Under favorable conditions of temperature and moisture this whole process requires only 14 days, the average time being 14 to 20 days. The adults do not feed on the developing seed; only the larva does injury in this way.

The midge appears first in the spring on Johnson grass and breeds there sufficiently to infest cultivated sorghums in considerable numbers as soon as the crops come into head. All sorghums are subject to its attacks, and it has been found also on foxtail and certain other wild grasses. Absence of the cultivated sorghums from any community throughout an entire year is therefore not disastrous to the midge. It lives over winter in the larval state in heads of the sorghums and Johnson grass which remain as trash on the fields or along the fence rows. Parasites become numerous usually late in the season and destroy large numbers of the midge, but too late to prevent the greater part of their injury to the sorghums.

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[15] Webster, F. M. The chinch bug. U. S. Dept. Agr., Farmers' Bul. 657. 28 p., 9 fig. 1915.

[16] Dean, W. Harper. The sorghum midge. *In* U. S. Dept. Agr., Bur. of Ent. Bul. 85, pt. 4, p. 39–58, fig. 20–31, 2 pl. 1911.

One way of combating the sorghum midge is by seeding very early in the season, so that the sorghums will come into bloom at a time when the midge is not plentiful.[17] Early seeding and careful harvesting of sorghum fields, together with the destruction of all the Johnson grass in adjoining areas, will lessen the evil, but may not completely overcome it. The damage from a forage standpoint is slight, as the sorghum makes good fodder even when it has failed to form seed, but the lack of home-grown seed of the better forage varieties no doubt tends to decrease the acreage of this crop in the midge-infested States.

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[17] Ball, Carleton R., and Hastings, Stephen H. Grain-sorghum production in the San Antonio region of Texas. U. S. Dept. Agr., Bur. Plant Industry Bul. 237, 30 p., 4 fig. 1912.

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FARMERS' BULLETIN 1159

FERMENTED PICKLES

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UNITED STATES DEPARTMENT OF AGRICULTURE

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Issued December, 1920; revised July, 1922

FERMENTED PICKLES.

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INTRODUCTION.

The cucumber is one of the oldest of the garden vegetables. Taking its origin in the Far East, probably in India, some 3,000 years ago, it has gradually spread, until to-day it is found under cultivation in some form in practically every country in the civilized world.

As a fresh vegetable the cucumber has a most refreshing and appetizing flavor, and is held in high esteem by the great majority of people. It is, however, in the making of pickles that the cucumber finds its chief value, being, above all other vegetables, well adapted to this purpose. As a result, there are few homes in this country in which cucumber pickles in some form do not find a place in the dietary.

The great demand for pickles among all classes early led to their production on a commercial basis, and this now constitutes a large and growing industry in which much capital is invested and many people given employment. The introduction of salting stations in those sections where cucumbers can be grown to good advantage has resulted in stabilizing the supply. At these stations cucumbers are cured in large quantities and held in reserve. Consequently the markets are fairly well supplied at all times with pickles, regardless of a failure of the crop in any season or in any locality.

Many housewives, however, prefer to make their own pickles, a commendable practice where the home garden affords a liberal supply of cucumbers. This bulletin deals only with the home production of pickles. It presents in the simplest way possible the essential processes involved, as well as the methods by which it is believed the standard and well-known varieties of pickles can be successfully prepared in the home.

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[1] The author wishes to acknowledge the valuable aid given by Dr. Charles Thom, chief of the Microbiological Laboratory, in conducting the investigations reported in this bulletin, as well as the assistance rendered by J. W. Sale, of the Bureau of Chemistry, W. D. Collins, of the Geological Survey, and D. N. Shoemaker and W. W. Gilbert, of the Bureau of Plant Industry.

CULTIVATION OF THE CUCUMBER.

Although normally a lover of subtropical conditions, the cucumber can be grown successfully in almost any part of the United States, provided care is taken to avoid exposure to frost. The best soil for its growth is a sandy or clay loam, but it can be grown on practically any soil that will produce good corn or potatoes. The best results, however, are obtained only when the soil is well fertilized, well-rotted stable manure being as good as anything for this purpose, although commercial fertilizers are often used to good advantage.

In gathering the crop, from one-eighth to one-fourth inch of the stem should be left on the cucumber, and care should be taken to avoid bruising it.

Certain varieties of cucumbers produce fruits which because of their shape, firmness, or keeping quality are better adapted to pickling purposes than others. When this is the end in view, these varieties should be selected in preference to the more rapid-growing and less resistant varieties of the market type. Among the best known of the pickling varieties are the Chicago Pickling, Boston Pickling, and Snow's Perfection. Cucumbers of practically all varieties, sizes, and shapes, however, may be utilized for pickling. This fact should be kept in mind in those localities where cucumbers are largely grown for the market, and, in fact, by all truck gardeners who raise this crop.

Complete information on the cultivation of the cucumber and the prevention of the diseases and enemies which attack it may be obtained from the following publications issued by the United States Department of Agriculture:

Farmers' Bulletin 254, Cucumbers, by L. C. Corbett.

Farmers' Bulletin 460, Frames as a Factor in Truck Growing, by W. R. Beattie.

Farmers' Bulletin 856, Control of Disease and Insect Enemies of the Home Vegetable Garden, by W. A. Orton and F. H. Chittenden.

Farmers' Bulletin 934, Home Gardening in the South, by H. C. Thompson.

Farmers' Bulletin 937, The Farm Garden in the North, by James H. Beattie.

Farmers' Bulletin 1038, The Striped Cucumber Beetle and Its Control, by F. H. Chittenden.

Farmers' Bulletin 1044, The City Home Garden, by W. R. Beattie.

Department Bulletin 727, Anthracnose of Cucurbits, by M. W. Gardner.

Department Bulletin 828, Bacterial Wilt of Cucurbits, by Frederick V. Rand and Ella M. A. Enslow.

Department Bulletin 879, The Mosaic Disease of Cucurbits, by S. P. Doolittle.

KEEPING CUCUMBERS.

Whenever cucumbers are grown in such quantities that they do not find ready sale in the markets as a fresh vegetable, they should be placed at once in brine and converted into either salt or dill pickles. The method of doing this is very simple, entailing but little expense aside from the cost of the barrels used as containers. After being cured they can be kept as long as desired or until it becomes possible to sell them to good advantage, either in local markets or to pickle manufacturers. Thus the grower is protected against a loss by overproduction or from inability to speedily market a crop which spoils readily, and at the same time the pickle market has the benefit of a more steady and ample supply.

FERMENTATION OF CUCUMBERS.

The proper curing of cucumbers for the production of pickles is accomplished by a lactic fermentation in brine. The use of brine is necessary for two reasons: (1) By the osmotic force which it furnishes the juice of the cucumbers is withdrawn to form part of the brine. Brine also causes a hardening or firmness of the cucumber tissue. (2) The presence of salt checks the action of spoilage organisms. At the beginning of a fermentation, before sufficient acid has been formed, and later when the amount of acid has decreased, these organisms probably would attack and break down the cucumber tissue.

Cucumbers contain approximately 90 per cent of water. This water, which is extracted by the osmotic action of the brine, includes the fermentable sugar, one of the constituents of the cucumber. The sugar content of cucumbers varies from 0.5 to 2.5 per cent, depending upon the variety, and upon soil and climatic conditions. Usually it is sufficient to afford nourishment for the growth of the acid-forming bacteria, as a result of the growth of which it is split up, to form lactic and probably, to some extent, certain volatile acids. By its reaction upon the cellular structure of the cucumber the acid brine thus formed brings about those changes in color, taste, and texture which are recognized as constituting the pickled state. In other words, the cucumber ceases to be a cucumber and becomes a pickle.

As the large water content of cucumbers reduces materially the salt concentration of any brine in which they are fermented, it is necessary to add an excess of salt at the beginning of a fermentation, in the proportion of 1 pound for every 10 pounds of cucumbers fermented.

The active stage of a cucumber fermentation continues for a period of from 10 to 30 days, depending largely upon the temperature at which it is conducted. As determined by the optimum requirement of the essential organisms, the most favorable temperature is approximately 86° F.

Practically all the sugar withdrawn from the cucumbers is utilized during the stage of active fermentation, at the end of which period the brine reaches its highest degree of acidity. During this period the salt concentration should not be materially increased, for although the lactic bacteria are fairly tolerant of salt, there is a limit to their tolerance. The addition of a large amount of salt at this time would reduce their acid-forming power just when this is essential to a successful fermentation. Salt, therefore, should be added gradually over a period of weeks. From one to two months is necessary for the complete curing of pickles. This is indicated by an increased firmness in texture, a greater degree of translucency, and a change in color from a pale green to a dark or olive green. These changes are uniform throughout the perfectly cured specimen. So long as any portion of a pickle presents a whitish or opaque appearance it can not be said to be perfectly cured.

EQUIPMENT AND SUPPLIES FOR BRINING AND PICKLING.

For the fermentation of vegetables in the home, stone jars are the most convenient and desirable receptacles. Stoneware is much more easily kept clean, and tends to absorb objectionable odors and flavors to a much smaller degree than wood. For purposes of fermentation, only the straight-sided, open-topped form of jar should be used. These can be obtained in almost any size desired, from 1 up to 20 gallons. As a rule, those holding 4 or 6 gallons are the most desirable. When larger quantities of food are to be packed kegs or barrels may be used, but only after they have been thoroughly washed, or possibly charred, in order to remove any undesirable flavors or odors which might be imparted to the foods packed in them. Undesirable flavors may be removed also from barrels by the use of solutions of caustic soda or potash. When strong lye is employed for this purpose it should be allowed to remain in the barrel for several days, after which the barrel is thoroughly soaked and washed with hot water until the alkali is removed. Wide-mouthed bottles or glass jars may be used when very small quantities of food are to be fermented or salted.

For covers, round boards, about 1 inch thick, are the most desirable. These can be made of any kind of wood except yellow or pitch pine, which would impart undesirable flavors to the vegetables. Covers should be from 1 to 2 inches less in diameter than the inside of the jar, so that they may be removed easily. Board covers are greatly improved by first dipping them in hot paraffin and then burning them over with a flame. In this way the pores of the wood are filled and the covers can be kept clean comparatively easily. For small containers, heavy plates of suitable size may be used instead of boards, if preferred.

After packing the material in the jar it is often desirable to cover it with a clean white cloth. Cheesecloth or muslin answers this purpose best. Two or three thicknesses of cheesecloth, cut in circular form and about 6 inches larger in diameter than the inside of the jar, afford a suitable covering. Sometimes grape, beet, or cabbage leaves are used for this purpose. Grape leaves make a good covering for dill pickles, and cabbage leaves for sauerkraut.

In all cases where vegetables fermented in a weak brine are to be kept for any length of time, it is necessary to exclude air by sealing with paraffin, beeswax, or oil, to prevent spoilage. Paraffin is cheaper than beeswax and oil, and probably preferable. It should be poured over the surface while hot in quantities sufficient to make, when cooled, a solid coating about ½ inch thick. This will effectually seal the jar, excluding the air and anything which might contaminate the contents. In packing vegetables for fermentation it is desirable that sufficient weight be placed on the cover to make the brine come up to but not over the cover. It is then necessary that only the portion of the surface around the cover be sealed with paraffin. Paraffin has the further advantage of being easily handled and readily separated from the fermented vegetables when they are removed from the container. If it becomes dirty, the dirt may be removed by first heating the paraffin to a high temperature and then straining it through several thicknesses of cheesecloth. In this way it can be used over again. It should not be applied until active fermentation has ceased, as the formation of gas below the layer might break the seal. In this event it would be necessary to remove it, heat it again, and replace it. It is also to be borne in mind that paraffin may be attacked by vermin, so that when it is used as a seal provision should be made to prevent such attacks. When jars are used this is accomplished by means of the lids.

Almost anything which furnishes the required amount of pressure will serve as a weight to hold down the mass in a jar or keg. Clean stones (except limestone) and bricks are effective.

A pair of kitchen scales and suitable vessels for determining liquid measure are, of course, an essential part of the equipment for brining and pickling.

Fine table salt is not necessary, nor in fact desirable, for salting vegetables or making up brine. What is known as common fine salt, usually sold in bulk at about 2 cents a pound, or even a coarser salt, such as is used in freezing ice cream, is better adapted to this purpose. It is important, however, that the salt should be as nearly as possible a pure sodium chlorid. Chemical impurities should not exceed 1 per cent. If present in larger amounts, they may interfere seriously with the success of a fermentation.

Spices are used to some extent in the production of nearly all kinds of pickles, chiefly, however, in making sweet, mixed, and dill pickles. Various combinations of spices are used, depending upon the kind of pickles to be made and also upon the flavor desired. The following whole spices are used in pickling:

- Peppers, black and cayenne.
- Cloves.
- Cinnamon.
- Celery seed.
- Caraway.
- Dill herb.
- Mustard, yellow.
- Allspice.
- Cardamom.
- Bay leaves.
- Coriander.
- Turmeric.
- Mace.

Ginger and horse-radish root are also sometimes used. Any of these spices may be purchased in bulk and mixed as desired. Mixed whole spices, specially prepared for pickling purposes, sold in the stores, are as a rule satisfactory. Care should be taken to see that they are of proper strength.

Oil spices, which are sometimes used, may be desirable under certain circumstances. Their effect, however, is less lasting than that of the whole spices, which are to be preferred.

Turmeric has been much used in both the commercial and household preparation of pickles. While certain of its qualities undoubtedly entitle it to be classed among the spices, it does not rank in importance as such with the others named. It is employed largely because of its supposed effect on the color of pickles. As a coloring agent its value is probably overestimated.

Dill herb (*Anethum graveolens*) is practically always used with cucumbers when they are fermented in a weak brine, and often with other vegetables fermented in this way. It gives to the pickle a distinct flavor which is very popular. The dill herb, a native of southern Europe, can be grown in nearly all parts of this country, and usually is obtainable in the markets of the larger cities. While the entire stalk of the dill herb is of value for flavoring, the seeds are best suited for imparting the desired flavor. For this reason the crop should not be harvested until the seeds are fully mature, and should be harvested before the seeds become so ripe that they fall off. The herb may be used green, dried, or brined. When green or brined dill is used, take twice the quantity by weight as would be required if the dried herb were used. Dill retains its flavor for a long time when brined. To preserve it in this way, it should be packed in a 60° brine, or if it is to be kept for a long time in an 80° brine. Dill brine is as useful as the herb for flavoring.

The salinometer, an instrument for measuring the salt strength of a brine, is very useful, though not absolutely essential, in brining. By following the directions given in this bulletin it will be possible to make up brines of the required strength without the use of this instrument. Results may be checked up readily, however, and any changes in brine strength which may occur from time to time detected by the use of the salinometer. The salinometer scale is graduated into 100 degrees which indicate the range of salt concentration between 0°, the reading for pure water at 60° F., and 100°, which indicates a saturated salt solution (26½ per cent). By reference to Table 1 (page 20), the relation between salinometer readings and salt percentages may be readily determined. Salinometers are sold by firms dealing in chemical apparatus and supplies for about $1 each.

SALT PICKLES.

In the household, where pickles usually are made in small quantities, stone jars constitute very useful receptacles. A 4-gallon jar, which will hold approximately 12 pounds (¼ bushel) of cucumbers, is a convenient size.

Wash the cucumbers if dirty, pack them in the jar, and cover with 6 quarts of a 10 per cent brine (40° on salinometer scale). At the time of making up the brine, or not later than the following day, add more salt at the rate of 1 pound for every 10 pounds of cucumbers used, in this case 1 pound and 3 ounces. This is necessary in order to maintain the strength of the brine. Cover with a round board or plate and on top of this place a weight heavy enough to keep the cucumbers well below the surface. At the end of one week and of each succeeding week for 5 weeks add (in this case) ¼ pound of salt. In adding salt always place it on the cover. If the salt is added directly to the brine it may sink to the bottom, as a result of which the salt solution at the bottom would be very strong, while that near the surface might be so weak that the pickles would spoil. A scum, made up usually of wild yeasts and molds, will form on the surface. As this may prove injurious by destroying the acidity of the brine, it should be removed by skimming.

Clean, water-tight barrels should be used in making larger quantities of pickles. With a barrel holding from 40 to 45 gallons, proceed as follows: Put into the barrel from 5 to 6 inches of a 40° brine (Table 1, page 20). To this brine it is well to add 1 quart of good vinegar. In this brine place the cucumbers as they are gathered. To keep the cucumbers below the brine, put a loose wooden cover over them and weight it with a stone heavy enough to bring the brine over the cover. The cucumbers should be weighed each time before they are added. After the cover and stone have been replaced add to the brine over the cover 1 pound of salt for every 10 pounds of cucumbers added.

If the cucumbers are not added too rapidly it will be unnecessary to add more brine, for when a sufficient weight is maintained on the cover the cucumbers make their own brine. If, however, the cucumbers are added rapidly, or if the barrel be filled at once, more brine may be required. In such a case add a sufficient amount of the 40° brine to cover the cucumbers.

When the barrel is full, add 3 pounds of salt each week for 5 weeks (15 pounds to a 45-gallon barrel). In adding the salt place it on the cover. Added in this way it goes into solution slowly, insuring a brine of uniform strength throughout and a gradually increasing salt concentration. Thus shriveling of the pickles is prevented to a great extent and the growth and activity of the lactic bacteria are not seriously checked. Stirring or agitation of the brine is not advisable and may be harmful for the reason that the introduction of air bubbles is conducive to the growth of spoilage bacteria. The scum which forms from time to time on the surface should be removed.

If the cucumbers are kept well under the brine and salt is added in the proportion indicated, it will not be necessary to exclude the air or seal in any manner.

Pickles prepared in this way are known as salt pickles (or salt stock). If they are well covered by the brine and if the surface remains clean they should keep indefinitely. A proper curing requires from 6 weeks to 2 months or possibly longer, according to the temperature at which it is carried out and the size and variety of cucumbers used.

After a partial soaking in water to remove excess of salt, these cucumbers may be eaten as salt pickles. Many prefer them in this form. Most people, however, like them better after they have been given an additional treatment in vinegar alone, or in vinegar combined with sugar and spices. Whatever the final disposition, pickles should first receive this perfect curing in brine. Attempts to use short cuts or to make pickles "over night," as is sometimes advised, are based on an erroneous conception as to what really constitutes a pickle.

PROCESSING AND SORTING SALT PICKLES.

After being cured in brine, pickles must receive a processing in water to remove the excess of salt. If they are to be used as salt pickles, only a partial processing is required. If, however, they are to be made into sour, sweet, or mixed pickles, the salt should be to a great extent, though not completely, removed. Pickles keep better when the salt is not entirely soaked out. Under factory conditions, processing is readily accomplished by placing the pickles in tanks, which are then filled with water and subjected to a current of steam, the pickles being agitated meanwhile. In but few homes, however, is the equipment for such treatment available. The best that can be done is to place the pickles in a suitable vessel, cover them with water, and heat them slowly to 120° F., at which temperature they should be held for from 10 to 12 hours, being stirred frequently. The water is then poured off, and the process repeated. It may be necessary to repeat it several times, especially if the pickles are large. The number of times can be determined by tasting the product.

After processing, the pickles should be sorted, an important step in reference to their further treatment. In order to secure the best appearing product, pickles should be as nearly as possible of uniform size. At least three sizes are recognized—small, medium, and large. If intended for bottling, only the small sizes are selected. Fairly small and medium sizes are well adapted to the making of sweet pickles. The larger sizes may be used for sour and dill pickles. Imperfectly formed pickles, the so-called crooks and nubs, can be well utilized by being cut up and added to mixed pickles or other combinations of which cucumbers form a part.

SOUR PICKLES.

After pickles have been processed sufficiently, drain them well, and cover them at once with vinegar, using a good clear vinegar[1] of 40 to 60 grain strength (4 to 6 per cent of acetic acid). If fruit vinegars are employed, they should be well filtered first, to remove all sediment. It is believed that a 40 or 45 grain vinegar gives all the sourness that is desirable. If, however, very sour pickles are preferred, it would be well to use, at first, a 40 grain vinegar, and after a week or 10 days transfer the pickles to a vinegar of the strength desired.

SWEET PICKLES.

In order to make sweet pickles, it is necessary to cover the cured and processed cucumbers with a sweet liquor, made by dissolving sugar in vinegar, with the addition usually of spices. For this purpose, a good, clear vinegar and granulated sugar are recommended. Other forms of sugar may be used but they are not as satisfactory. The amount of sugar taken depends upon the degree of sweetness desired. It may vary from 4 to 10 pounds to the gallon of vinegar, 6 pounds to the gallon usually giving satisfactory results. The chief difficulty in making sweet pickles is due to the fact that they often become shriveled and tough. This danger increases with the sugar concentration of the liquor, and usually can be avoided by covering the pickles first with a plain 40 to 45 grain vinegar, adding the sugar 10 days later. If a liquor containing more than 4 pounds of sugar to the gallon is desired, it would be best not to exceed that amount at first, but gradually add sugar until the desired concentration is obtained. If a saccharometer is at hand this can be very readily and accurately accomplished. For this purpose use a Brix or Balling saccharometer graduated from 0° to 70°. A reading of 42° on the Balling scale would indicate a sugar concentration of approximately 6 pounds of sugar to the gallon of vinegar (Table 3, p. 21).

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[1] Many pickle manufacturers prefer to use distilled vinegar, for the reason that it is colorless and free from sediment.

Spices are practically always added in making sweet pickles. These should not, however, be used in too large a quantity. The effect of too much spice, especially the stronger varieties, like peppers and cloves, is injurious rather than beneficial. One ounce of whole mixed spices to 4 gallons of pickles and a proportionate amount for a less quantity is ample. As spices may cause cloudiness of the vinegar, they should be filtered out after the desired flavor has been obtained to secure the best-appearing product. A better utilization of spice is secured by the aid of heat. Add the required amount of spice to the vinegar and hold at the boiling point for not longer than one-half hour. Heating too long causes darkening of the vinegar. Filter out the spices by pouring the mixture through cheesecloth. If considered desirable add sugar at this time and pour at once over the pickles.

In case the pickles are to be packed in bottles or jars, after such preliminary treatment as may be required, transfer them to these containers, and cover with a liquor made up as desired.

MIXED PICKLES.

For making mixed pickles various combinations of vegetables are used, depending upon the mixture desired and the available supply. In addition to cucumbers, onions, cauliflower, green peppers, tomatoes, and beans are well suited to this purpose. All vegetables which are used in making mixed pickles should first be properly cured in brine, just as in the case of cucumbers.

For making mixed pickles very small vegetables are much to be preferred. If larger ones must be used, they should first be cut into pieces of a desirable and uniform shape and size.

For containers use wide-mouthed bottles or jars. Place in the bottom of each a small amount of mixed spice. In filling the bottle arrange the various kinds of pickles in as neat and orderly a manner as possible. The appearance of the finished product depends largely upon the manner in which they are packed in the bottle. Do not fill the bottles entirely.

If sour pickles are desired, fill the bottles completely with a 40 grain vinegar. If sweet, fill with a liquor made by dissolving from 4 to 6 pounds of sugar in a gallon of vinegar.

Seal tight and label properly. If wood corks are used for sealing, they should first be dipped in hot paraffin.

DILL PICKLES.

The method for making dill pickles differs from that for making salt pickles in two important particulars: (1) A much weaker brine is used, and (2) spices are added, chief of which is dill. Dill herb, the entire stalk of which is used, gives a distinctive flavor to pickles.

By reason of the weaker salt concentration, a much more rapid curing of the pickles takes place. As a result they can be made ready for use in about half the time required for ordinary brined pickles. This shortening of the period of preparation, however, is gained at the expense of the keeping quality of the product. For this reason it is necessary to resort to measures which will prevent spoilage.

For making dill pickles in the home, use stone jars, or clean, water-tight kegs or barrels. If a 4-gallon jar is used, proceed as follows: Place in the bottom a layer of dill and ½ ounce of mixed spice. Then fill the jar to within two or three inches of the top with washed cucumbers which are as uniform in size as possible. Add another ½ ounce of spice and layer of dill. If they can be obtained, it is a good plan to place over the top a layer of grape leaves. In fact, it would be well to place these at both the bottom and top. They make a very suitable covering and have been found to have a greening effect on the pickles. Pour over the pickles a brine made up as follows: Salt, 1 pound; vinegar, ¾ quart; and water, 10 quarts. Cover with a board cover or plate with sufficient weight on top to hold the cucumbers well below the brine. If the cucumbers are packed at a suitable temperature (about 86° F.), an active fermentation will at once set in. This should be completed in from 10 days to 2 weeks, if a temperature of about 86° F. is maintained. A scum soon forms on the surface. This consists usually of wild yeasts, but often contains molds and bacteria, and should be skimmed off.

After active fermentation has ceased, it is necessary to protect the pickles in some way against spoilage. This may be done in one of two ways: (1) Cover with a layer of paraffin. This should be poured while hot over the surface or as much of it as is exposed around the edges of the board cover. When cooled this forms a solid coating which effectually seals the pickles. (2) Seal the pickles in glass jars or cans. As soon as it is found that they are sufficiently cured, which may be determined by their agreeable flavor and dark-green color, transfer them to glass jars (2-quart size), and fill with a fresh brine made as directed. Add a small amount of dill and spice. In this case it is well to bring the brine to a boil, and, after cooling slightly, pour it over the pickles. Seal the jars tight.

In this connection it may be well to call attention to the fact that in no case should a hot brine be used at the start of a fermentation. In all probability the hot brine would kill the organisms present, thus preventing any fermentation.

The plan of preserving dill pickles by sealing in jars has the merit of permitting the use of a small quantity without the necessity of opening up and again resealing a large bulk, as is the case when pickles are packed in large containers and sealed with paraffin.

If it is desired to put up dill pickles in barrel lots, select none but clean, tight barrels. Anything in the barrels which would give the pickles an " off " flavor must be removed. A careful observance of this precaution may save much trouble and disappointment.

Fill the barrel with washed cucumbers, adding from 6 to 8 pounds of green or brined dill, or half that amount of dry dill, and 1 quart of mixed spices. If brined dill is used, it is well to add about 2 quarts of the dill brine. The dill and spices should be evenly distributed at the bottom, middle, and top of the barrel. Also add 1 gallon of good vinegar.[1] Head up tight and through a hole bored in the head fill the barrel with a brine made by adding salt in the proportion of ½ pound to the gallon of water. Add brine until it overflows the head and is level with top of the chimb. This level should be maintained by adding brine from time to time as required. Remove the scum which soon forms on the surface. During the period of active fermentation the barrel should be kept in a warm place, and the hole in the head should remain open to allow gas to escape. When active fermentation is over, as indicated by the cessation of bubbling and frothing on the surface, the barrel may be plugged up tight and placed in storage, preferably in a cool place. It is well to bear in mind, however, that, on account of leakage and other causes, the brine in a barrel of pickles may recede at any time. Occasional inspection, therefore, should be made to determine this matter, and, if necessary, more brine added. Pickles put up in this way should be ready for use within about 6 weeks.

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[1] The addition of vinegar is not essential in the making of dill pickles, and many prefer not to use it. Its use, however, in the proportion indicated would be favorable to the growth of the lactic bacteria and at the same time would be inhibitive, to some extent at least, to the growth of spoilage organisms. Its use, therefore, is to be regarded with favor. Some prefer also to omit the use of mixed spices for the reason that they interfere with the distinctive flavor of the dill herb which by many is considered most desirable.

In case it is desired to hold the pickles in storage for a long time, it would be advisable to use a brine somewhat stronger than that indicated. A 28° brine, made by adding 10 ounces of salt to a gallon of water, is used for this purpose. Pickles packed in a brine of this strength will keep a year if the barrels are kept filled and in a cool place. The important factor in preserving pickles put up in a weak brine, such as is ordinarily used for dill pickles, is the exclusion of air. When put up in tight barrels this is accomplished by keeping the barrels entirely filled with brine.

SAUERKRAUT.

Fermented salt cabbage, commonly called sauerkraut, is a form of food which has much to commend it to popular favor. The making of sauerkraut offers a good means of utilizing surplus stocks of cabbage and at the same time affords a food which to most people is both palatable and wholesome. It also enables the housewife to carry over into the winter months a form of vegetable food which helps to vary the diet at a time when this often consists too largely of meat.

For making sauerkraut in the home 4- or 6-gallon stone jars constitute the best containers, unless very large quantities are desired, in which case kegs or barrels may be used.

Select only mature, sound heads of cabbage. After removing all decayed or dirty leaves, quarter the heads and slice off the core portion. For shredding, one of the hand shredding machines which can be obtained on the market is much the best, although an ordinary slaw cutter or a large knife will do.

In making sauerkraut the fermentation is carried out in a brine made from the juice of the cabbage which is extracted by the action of salt. One pound of salt for every 40 pounds of cabbage makes the proper strength of brine to produce the best results. This may be distributed as the cabbage is packed in the jar or it may be mixed with the shredded cabbage before being packed. Thus, the distribution of 2 ounces of salt with every 5 pounds of cabbage probably is the best way to secure an even distribution. The cabbage should be packed firmly but not too tightly in the jar or keg. When full, cover with a clean cloth and a board cover or plate. On the cover place a weight heavy enough to cause the brine to come up to the cover. If the jar is kept at a temperature of about 86° F., fermentation will start promptly. A scum soon forms on the surface. As it tends to destroy acidity and may injure the cabbage beneath, it should be skimmed off from time to time. If kept at the temperature indicated the fermentation should be completed in from 6 to 8 days.

A well-fermented sauerkraut should show a normal acidity of approximately +20 or a lactic acid percentage of 1.8 (p. 21).

After fermentation is complete, the kraut should be set in a cool place. If the cabbage is fermented late in the fall or if it can be stored in a very cool place, it may not be necessary to do more than keep the surface skimmed and protected from insects, etc. Otherwise, it will be necessary to resort to measures to prevent spoilage. This may be done, as suggested in the case of dill pickles, by one of two methods: (1) A layer of hot paraffin may be poured over the surface, or as much of it as is exposed around the cover. Properly applied to a clean surface, this effectually seals the jar and protects the contents from contamination. (2) After the fermentation is complete, pack the kraut in glass jars, adding enough of the kraut brine, or, in lieu of this, a weak brine made by adding 1 ounce of salt to a quart of water, to completely fill the jars. Seal the jars tight, and set them away in a cool place. This method of preserving sauerkraut just as in the case of dill pickles is much to be preferred. Kraut properly fermented and stored in this way has been found to keep throughout a season in good condition. When made commercially where conditions and length of storage can not be controlled the use of heat in the process of canning is essential.

FERMENTATION AND SALTING AS A MEANS OF PRESERVING VEGETABLES.

Vegetables other than cucumbers and cabbage may be preserved by means of a lactic fermentation in brine. This may be accomplished by either of the two methods already discussed, namely, fermentation in brine produced by dry salting or fermentation in an added brine.

The first method, of course, is applicable only to those vegetables which contain a sufficient amount of water to make their own brine. The best example of this is found in cabbage (p. 15). String beans, however, if young and tender, may well be preserved in this way. To do this, remove tips and strings, and, if large, break into two pieces. Use 3 per cent salt.

Many vegetables can be well fermented in an added brine. This is the only plan available for those which do not contain enough water to make their own brine. For this purpose use a brine made by adding ½ pound of salt and ½ pint of vinegar to a gallon of water. Dill and spices may be added, if desired. String beans, green tomatoes, beets, chayotes, peas (shelled), and corn (on cob) may be preserved in this way. To preserve vegetables successfully in this way, follow the general directions given for making dill pickles (p. 13).

Another method which may be chosen for preserving vegetables is that of dry salting without fermentation. To do this, sufficient salt must be added to prevent all bacterial action. Wash and weigh the vegetables. Then mix with them thoroughly one-fourth their weight of salt. If after the addition of pressure not enough brine to cover the product is formed; add brine made by dissolving 1 pound of salt in 2 quarts of water. As soon as bubbling ceases, protect the surface by covering with paraffin. Corn can be well preserved in this way. It is first husked and the silk removed, after which it is cooked in boiling water for 10 minutes to set the milk. The corn is then cut from the cob with a sharp knife, weighed, and packed in layers with one-fourth its weight of fine salt. This method is especially well adapted to those vegetables in which the sugar content is too low to produce a successful fermentation, such as chard, spinach, and dandelions.

The methods of food preservation outlined are not necessarily limited to vegetables. Solid fruits, like clingstone peaches and Kieffer pears, can be preserved in an 80° brine for as long as 6 months, when, after the salt has been soaked out, they may be worked up into desirable products by the use of spices, vinegar, sugar, etc. Soft fruits, like Elberta peaches and Bartlett pears, are best preserved in a weak vinegar (2 per cent acetic acid).[1]

The preservation of vegetable foods by lactic fermentation in brine and by dry salting is not to be recommended indiscriminately. Rather is this plan to be regarded in the light of an emergency measure. Experiments have shown very clearly that foods preserved by these methods lose decidedly in nutritive value as well as in natural flavor by the time they are ready for use. With the exception of the making of pickles and sauerkraut from cucumbers and cabbage, where fermentation is always to be regarded as a useful and desirable method of utilization, canning, as a rule, offers a better means of preserving both vegetables and fruits, because in this way the nutritive constituents and natural flavors of the food are more completely retained. Often, however, because of lack of time, a shortage of cans or an oversupply of a product, canning is out of the question. Under such conditions the possibilities of utilization by means of brining or salting should always be considered.

CAUSES OF FAILURE AND HOW TO AVOID THEM.

A soft or slippery condition is one of the most common forms of spoilage in making pickles. This is the result of bacterial action, and always occurs when pickles are exposed above the brine and very often when the brine is too weak to prevent the growth of spoilage organisms. Prevention lies in keeping the pickles well below the brine and the brine at the proper strength. Experiments have shown that in order to insure the keeping of pickles for more than a very few weeks a brine should contain 10 per cent of salt. Once pickles have become soft or slippery as a result of bacterial action, no form of treatment will restore them to a normal condition.

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[1] Report of an investigation made in the Bureau of Chemistry on the utilization of brined products, by Rhea C. Scott, 1919.

Hollow pickles sometimes occur during the process of curing. This is, indeed, one of the most frequent causes of failure in pickle making. This condition does not, however, mean a total loss, as in the case of softening, for the reason that such pickles may be utilized in the making of mixed pickles or certain forms of relish. Hollow pickles are generally believed to be the result of a faulty development or nutrition of the cucumber. While there are good reasons to believe that this trouble is inherent in the cucumber, there is also a strong probability that faulty methods may contribute to this condition. One of these is allowing too long a time to intervene between gathering and brining. This period should not exceed 24 hours.

Hollow pickles frequently become *floaters*. Sound cucumbers when properly cured do not float, but any condition which operates to lower their relative weight—such as gaseous distention—may cause them to rise to the surface.

The use of so-called hard waters should be avoided in making up a brine. The presence of large amounts of calcium salts and possibly of other salts found in many natural waters may prevent the proper acid formation and thus interfere with a normal curing of the pickles. The addition of a small amount of vinegar serves to overcome alkalinity and is valuable, especially where hard water must be used in making up brine (p. 9). Iron, if present in any appreciable amount, is very objectionable. The presence of iron, under certain conditions, may cause a blackening of the pickles.

Shriveling of pickles often occurs when they have been placed at once in very strong salt or sugar solutions or even in very strong vinegars. For this reason such solutions are to be avoided so far as possible. When their use is desirable, the pickles should first be given a preliminary treatment in a weaker solution. This difficulty is most often encountered in the making of sweet pickles. The presence of sugar in high concentrations is certain to cause shriveling unless proper precautions are taken. These have already been discussed (p. 11).

Perhaps the most common cause of failure in making sauerkraut is the use of too much salt. A wide experience has shown that the proper amount is 2½ per cent by weight of the cabbage packed. When cabbage is to be fermented in very warm weather, it may be expedient to use a somewhat larger percentage of salt. As a rule, however, this should not exceed 3 per cent. In applying the salt, care should be taken to see that it is evenly distributed. Red streaks which sometimes occur in sauerkraut are believed to be due to an uneven distribution of salt.

Spoilage of the top layers of vegetables fermented in brine is very sure to occur unless the scum which forms on the surface is frequently removed. This scum is made up of wild yeasts, molds, and certain bacteria, which, if allowed to remain, attack and break down the vegetables beneath. They may also weaken the acidity of the brine, in which way they are conducive to spoilage. The fact that the top layers have spoiled does not necessarily mean, however, that the entire contents of the vessel are spoiled. The molds and other organisms which cause the spoiling do not penetrate rapidly to the lower layers. The part found in good condition may commonly be saved by carefully removing the spoiled material from the top, adding a little fresh brine, and pouring hot paraffin over the surface.

Temperature has an important bearing on the success of a lactic fermentation. It has been found that the bacteria which are essential in the fermentation of vegetable foods manifest their greatest activity at a temperature of approximately 86° F., and that as the temperature falls below this point their activity correspondingly diminishes. It is essential, therefore, that at the start and during the active stages of a fermentation these foods be kept as nearly as possible at 86° F. This is especially to be kept in mind in connection with the production of sauerkraut, which is often made in the late fall or winter. As a result of too low a temperature the fermentation may be much retarded or even an entire failure.

After the active stages of a fermentation have passed, the food should be stored in a cool place. Low temperatures always are conducive to the preservation of food products.

COLORING AND HARDENING AGENTS.

In order to secure a better looking product, the practice prevails in some households of greening pickles by heating them with vinegar in a copper vessel. Experiments have shown that pickles treated in this way take up very appreciable amounts of the copper acetate thus formed. All the copper salts are more or less toxic agents. By a ruling of the Secretary of Agriculture, made July 12, 1912, foods greened with copper salts are to be regarded as adulterated, and as such are subject to action under the provisions of the Food and Drugs Act of June 30, 1906.

Alum is much used and recommended for the purpose presumably of producing a greater degree of firmness in pickles. The use of alum in connection with food products is of doubtful expediency, to say the least. If the proper methods are followed in preparing pickles, the salt and acids in the brine will produce the desired degree of firmness. The use of alum or any other hardening agent is believed to be unnecessary.

MISCELLANEOUS INFORMATION.

TABLE 1.—*Salt percentages, corresponding salinometer readings, and amount of salt required to make 6 quarts of brine.*

Salt in solution.	Salinometer reading.	Amount of salt present in 6 quarts of finished brine.	Salt in solution.	Salinometer reading.	Amount of salt present in 6 quarts of finished brine.
Per cent.	*Degrees.*	*Ounces.*	*Per cent.*	*Degrees.*	*Ounces.*
1.06	4	2	8.48	32	18
2.12	8	4¼	9.54	36	20
3.18	12	6½	10.6	40	22½
4.24	16	8½	15.9	60	35
5.3	20	11	21.2	80	48
6.36	24	13	26.5	100	64
7.42	28	14½			

The figures given in the first two columns of Table 1 are correctly stated. Those in the last column are correct within the possibilities of ordinary household methods. In making up a brine from this table, first dissolve the required amount of salt in a smaller volume of water, then add water to make up as nearly as possible to the required 6 quarts.

One pound of salt dissolved in 9 pints of water makes a solution with a salinometer reading of 40°, or approximately a 10 per cent brine. In a brine of this strength fermentation proceeds somewhat slowly. Pickles kept in a brine maintained at this strength will not spoil. One-half pound of salt dissolved in 9 pints of water makes approximately a 5 per cent brine with a salinometer reading of 20°. A brine of this strength permits a rapid fermentation, but vegetables kept in such a brine will spoil within a few weeks unless air is excluded.

A brine in which a fresh egg just floats is approximately a 10 per cent solution.

Fermentation takes place fairly well in brines of 40° strength, and will, to some extent at least, up to 60°. At 80° all fermentative action ceases.

The amount of brine necessary to cover vegetables is equal to about one-half of the volume of the material to be fermented. For example, if a 5-gallon keg is to be packed, 2½ gallons of brine are required.

TABLE 2.—*Freezing point of brine at different salt concentrations.*

Salt.	Salinometer reading.	Freezing temperature.
Per cent.	*Degrees.*	° *F.*
5	20	25.2
10	40	18.7
15	60	12.2
20	80	6.1
25	100	0.5

TABLE 3.—*Density of sugar sirup.*

Density.	Quantity of sugar for each gallon of water.[1]		Density.	Quantity of sugar for each gallon of of water.[1]	
Degrees Brix or Balling.	*Lbs.*	*Ozs.*	*Degrees Brix or Balling.*	*Lbs.*	*Ozs.*
5		7	35	4	7.75
10		14.8	40	5	8.75
15	1	7.5	45	6	13
20	1	14.75	50	8	5.25
25	2	12.5	55	10	4
30	3	9	60	12	8

[1] When vinegar is used, the equivalent saccharometer reading would be about 2 degrees higher than that indicated in the table.

TABLE 4.—*Number of pickles of various sizes required to make a gallon.*

Size.	Variety.	Number to a gallon.
1 to 2 inches	Gherkins[1]	250 to 650
2 to 3 inches	Small pickles	130 to 250
3 to 4 inches	Medium pickles	40 to 130
4 inches and over	Large pickles	12 to 40

[1] Small pickles are usually designated as gherkins. Those of very small size are sometimes called midgets.

The maximum degree of acidity formed by a lactic fermentation of vegetables in brine varies from 0.25 to 2 per cent. The maximum acidity is reached at or soon after the close of the active stage of fermentation. After this period the amount of acid usually decreases slowly. The stage of active fermentation continues for from 1 to 3 weeks, depending upon the temperature, strength of brine, etc. During this period gas is formed, and more or less froth appears on the surface, due to the ascent of gas bubbles. At the close of this period the brine becomes "still."

The amount of acid formed depends primarily upon the sugar content of the vegetables fermented, but may be influenced by other factors. The fact that a brine has become acid may be determined by the use of litmus paper. Blue litmus paper dipped in an acid brine will become red. This does not, however, give definite information as to the degree of acidity. For those who may wish to determine accurately the degree of acidity in brines, the following method is given:

With the aid of a pipette, transfer exactly 5 cc. of the brine to a small evaporating dish. To this add 45 cc. of distilled water and 1 cc. of a 0.5 per cent solution of phenolphthalein in 50 per cent alcohol. Then run in slowly a 1/20 normal sodium hydrate solution. This is best done by the use of a 25 cc. burette graduated in tenths. As the sodium hydrate is being added stir constantly, and note carefully when the entire amount shows a faint pink tint. This indicates that the neutral point has been reached. Read off carefully the exact amount of sodium hydrate required to neutralize the mixture in the dish. This number multiplied by 0.09 gives the number of grams of acid per 100 cc., calculated as lactic, present in the brine.

This same method can be used to determine the acid strength of vinegars. In this case multiply by 0.06 to ascertain the number of grams of acetic acid per 100 cc. present in the vinegar.

The apparatus and chemicals needed for this test can be obtained from any firm dealing in chemical apparatus and supplies.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

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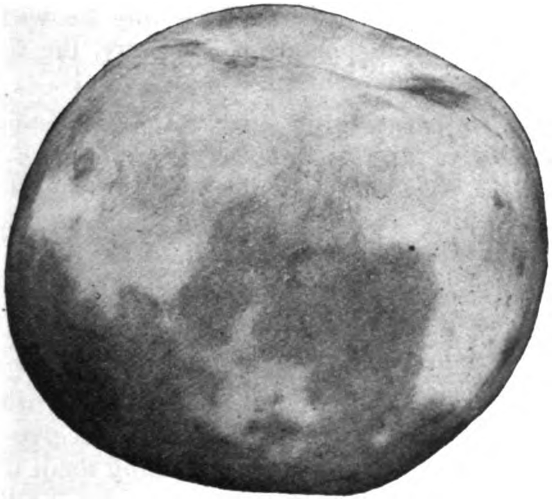

Scald on a York Imperial Apple

FARMERS' BULLETIN 1160
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

STORAGE DISEASES take a heavy annual toll on the harvested crop of apples, greatly reducing an important food supply and increasing the cost and uncertainty of market operations.

The responsibility for this loss may lie with the orchardist, the transportation company, the dealer, or the storage management.

Delay in warm packing sheds or cars shortens the natural life of apples and greatly increases their tendency to rots and to scald. Filling the storage rooms so rapidly that cold-storage temperatures can not be maintained has a similar bad effect.

Apple rots are slow to start at a temperature of 32° F., but if a beginning has been made at a higher temperature they can proceed much more rapidly.

Ventilation is as important as low temperature in the prevention of scald. Apples that receive good aeration when delays occur in handling them do not have their tendency to scald increased by the delay. Ventilation of storage rooms is of great value in scald prevention when the air within the package can really be renewed, but this is a difficult thing to accomplish under commercial conditions.

Apples scald far less when in boxes, baskets, or ventilated barrels than in the usual tight barrel.

Wrapping apples in oiled wrappers furnishes the most complete protection against scald.

DISEASES OF APPLES IN STORAGE.

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PRINCIPLES GOVERNING DISEASE CONTROL.

THE diseases that appear on apples in storage and upon their removal may be the result of storage conditions, or their occurrence may have been predetermined by orchard and transportation conditions. They may be due to the work of a parasite or to the direct action of unfavorable conditions upon the fruit itself. Diseases like scab and certain rots that are definitely traceable to the action of particular fungi are called parasitic diseases, while bitter-pit, water-core, and scald are known to be due wholly to abnormal physiological conditions in the fruit itself, and are called nonparasitic or physiological diseases. Both parasitic and nonparasitic diseases can be prevented largely by proper methods of growing and handling the fruit, but each disease has its own peculiar laws of behavior upon which the requirements for its control must be based.

SCAB.

Scab[1] is a parasitic disease and mainly an orchard disease. It can be largely controlled by carrying out the spraying schedules that have been developed and recommended for the different fruit sections. It is particularly serious in the orchards of the northeastern United States and in those of the humid sections of the Pacific Northwest, but it also occurs at the higher altitudes as far south as Virginia, North Carolina, and Arkansas.

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[1] *Venturia inoequalis* (Cke) Wint.

Scab may appear on the picked fruit as large corky or dark sooty spots with a light-gray margin or as small sooty spots or specks often irregular in outline and usually without the gray margin. (Fig. 1.) The latter form of the disease is the one that is most likely to pass into storage packages. With both the large and small spots the protecting skin is broken and the apple exposed to early destruction by the rot organisms. Pink-rot and blue mold are among the most common decays that follow scab.

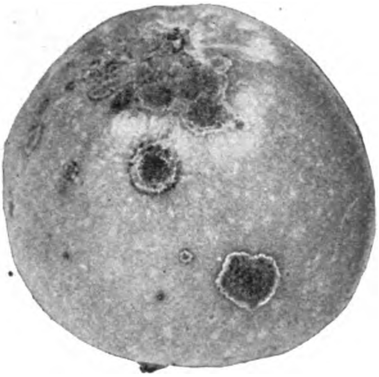

FIG. 1.—Scab as it appears at picking time on a White Pearmain apple.

Scab sometimes continues to develop in storage, but the characteristics of the spots are quite different from those found at picking time. They are smooth, black, and sunken, sometimes attaining a diameter of one-fourth of an inch before the fungus breaks through to the surface or causes any roughening of the skin. The development of the scab fungus is checked by low temperatures and ordinarily makes little trouble in cold storage except as a source of rot infections.

BLOTCH.

Blotch[1] is a parasitic orchard disease. It can be controlled by orchard sanitation and properly timed spray applications. It is a serious disease only in the more southern orchards of the Eastern and Middle States, but it seems to be gradually spreading northward.

Blotch appears on the fruit as hard brown or black blotches with jagged margins. The cuticle does not peel off, as with scab, but the protecting skin layers are killed and often broken by fissures and cracks. (Fig. 2.) Badly blotched apples are usually discarded or sold for immediate use, but those with a few small spots sometimes get into storage. The disease makes little, if any, development at cold-storage temperature, but the blotch spots may furnish a starting point for storage rots, particularly black-rot and Alternaria rot.

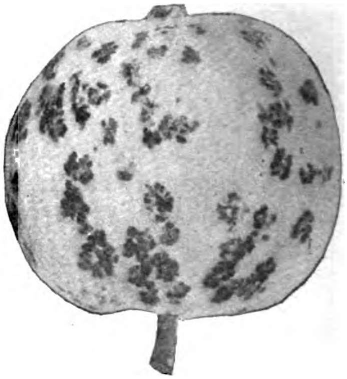

FIG. 2.—Blotch on a Ben Davis apple.

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[1] *Phyllosticta solitaria* E. and E.

FRUIT-SPOT.

Fruit-spot [1] is a parasitic disease readily controlled by midsummer spraying, yet often found in abundance on the harvested fruit. It is of common occurrence in the orchards of the Atlantic coast from Maine to North Carolina, and it also occurs in Ohio, Missouri, and Arkansas. It has also been described under the names fruit-speck, New Hampshire fruit-spot, and flecked spot, and is sometimes referred to as Brooks-spot and included in the term Baldwin spot.

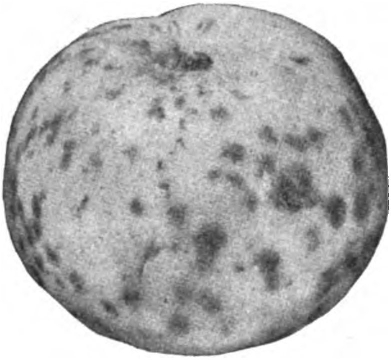

FIG. 3.— Fruit-spot on a Grimes apple.

The spots are small, seldom having a diameter of more than three-sixteenths of an inch. They are more highly colored than the normal skin, taking a deep red when on the red or blush areas and a dark green when on the green or yellow fruit surfaces. The center of the spot is usually specked or flecked with black, giving an appearance that does not occur in any other spot disease. (Fig. 3.) This flecked appearance is seen to better advantage after a very thin peel has been removed from the apple. The spots are shallow, usually affecting only the skin tissue. They may be slightly sunken, but usually at picking time have little or no corky tissue.

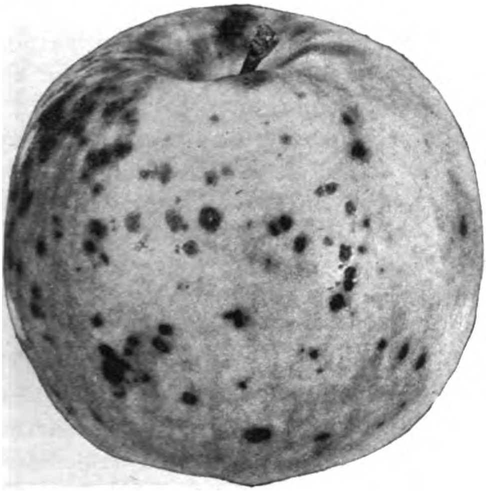

FIG. 4.—Jonathan spot on a Jonathan apple.

In common storage the fruit spots may become more sunken and develop a shallow layer of corky tissue beneath and the inconspicuous ones develop so that the spots appear more numerous. In cold storage they make no evident development. With fruit-spot the protecting skin layer is not destroyed, and, unlike scab and blotch, the disease does not serve as a source of rot infection. Apples affected with fruit-spot need not be discriminated against on account of their keeping quality in cold storage.

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[1] *Phoma pomi* Passer.

JONATHAN SPOT.

Jonathan spot is a nonparasitic disease and can not be controlled by spraying. It is apparently associated with a varietal weakness in the epidermal tissue of the apple. It is particularly common on Jonathan apples, but it occurs on the Stayman Winesap, Esopus (*Esopus Spitzenberg*), Wealthy, Rome Beauty, and a number of other varieties. The disease varies with the season, but is found in all sections where susceptible varieties are grown.

Jonathan spot appears as small black or brown spots that give the apple a somewhat freckled appearance. (Fig. 4.) In the earlier and more typical stages of the disease the spots are very superficial, usually being entirely removed by the thinnest possible peel; later they may become somewhat enlarged and develop a shallow layer of corky tissue immediately beneath. Jonathan spots differ from those of either fruit-spot or bitter-pit in being smaller and more superficial and in having a solid brown color and a clear-cut margin.

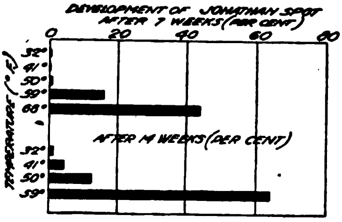

FIG. 5.—Effect of temperature on the development of Jonathan spot on apples. The upper part of the figure shows the percentage of Jonathan spot developed at the different temperatures at the end of 7 weeks; the lower part shows the percentage developed at the end of 14 weeks. At 68° F. the apples had rotted before the second record was taken.

Jonathan spot may occasionally appear on the fruit before it is picked, but the main development of the disease is after removal from the tree. In general, the highly colored apples are more likely to be affected than the greener ones, but in storage the greener apples sometimes develop a large proportion of Jonathan spot that closely resembles a speckled scald. Large apples usually are more susceptible to the disease than smaller ones. The disease is greatly decreased by low temperatures. (Fig. 5.) Fruit held in common storage has been found badly affected with Jonathan spot at the end of two weeks, while similar fruit placed immediately in cold storage has been entirely free from the disease at the end of 8 weeks and practically free at the end of 14 weeks. Apples that have a tendency to Jonathan spot sometimes develop the disease very rapidly upon removal from storage. The most effective means of control is found in hastening the fruit to cold storage and in keeping it as cool as possible after removal. Jonathan spots furnish a point of infection for Alternaria and other rot organisms.

BITTER-PIT.

Bitter-pit is a nonparasitic disease, apparently due to an excessive water supply late in the season or to related derangements in soil-moisture conditions. It occurs on apples in all sections of the United States and is a serious disease in Europe, South Africa, and Australia.

Bitter-pit has also been described under the names Stippen, Baldwin spot, and fruit-pit. In the United States the Baldwin, Grimes, Northern Spy, and Rhode Island Greening varieties are particularly susceptible to the disease.

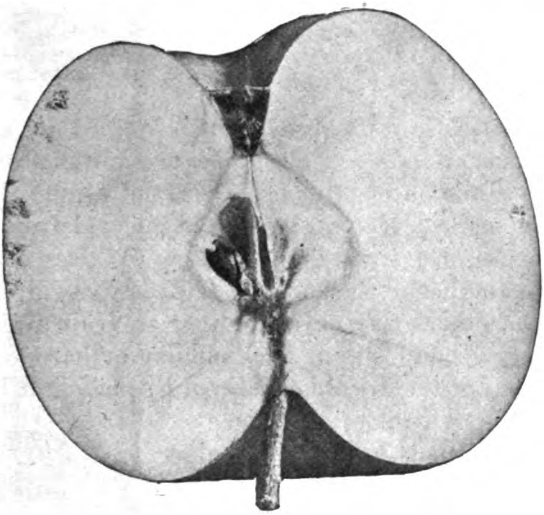

FIG. 6.—Bitter-pit on a Grimes apple as seen in cross section.

The disease is characterized by the development of small brown spots or streaks in the flesh of the apple, most abundant just beneath the skin. (Fig. 6.) The spots are associated with the water-conducting strands and sometimes follow this tissue deep into the flesh. The disease is usually evident on the surface of the apple as sunken, bruiselike spots that somewhat resemble hail injury. At first these spots have a water-soaked appearance, but later they may become more highly colored than the surrounding skin, taking a deep red when on a blush area and retaining a bright green when on a green or yellow fruit surface. They finally become a deep brown and are much sunken, giving the apple a badly pitted appearance. Bitter-pit is confined almost entirely to the blossom half of the apple. It differs from Jonathan spot and fruit-spot in this respect, and also in the fact that the spots are bruiselike, more sunken, contain more dead-brown tissue, and are more deeply seated. Jonathan spots and fruit spots are usually entirely removed in peeling an apple, but the bitter-pit spots are cut into and made more evident.

Bitter-pit is largely due to some overstimulation of the fruit during the latter part of the growing season. Heavy irrigation and heavy rainfall during the last weeks before picking are particularly favorable to the disease. (Fig. 7.) Cultivation, fertilizers, cover crops, pruning, thinning the fruit, and the age of the trees may all have a bearing on its occurrence. Everything that contributes to the stabilizing of the moisture conditions in the soil and to an even, normal growth of the fruit throughout the summer is of value in the prevention of the disease. Bitter-pit is worse on the fruit from young trees than on that from old ones. In general, it is worse on large apples than on small ones, yet susceptibility to the disease is determined not so much by size as by the time and nature of the orchard conditions which produce the growth.

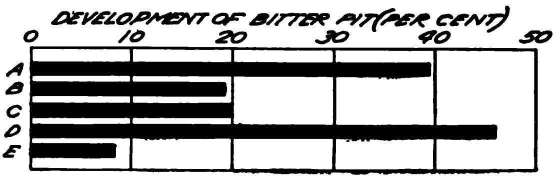

Fig. 7.—Effects of irrigation on the development of bitter-pit in storage on Grimes apples from Wenatchee, Wash. *A*, **Heavy irrigation throughout the season;** *B*, **medium irrigation throughout the season;** *C*, **light irrigation throughout the season;** *D*, **medium irrigation followed by heavy;** *E*, **heavy irrigation followed by light.**

While bitter-pit is largely, if not wholly, due to orchard conditions, its main development is after removal from the tree, in the packing house, in transit, or in storage. It does not spread from one apple to another in the package, but the spots already present may enlarge and others may develop either on fruit already affected or on seemingly sound apples from similar orchard conditions. The development of the disease is delayed by placing it immediately in cold storage, but fruit that shows a tendency to bitter-pit at picking time is seldom suited for late keeping.

DROUGHT-SPOT.

The terms drought-spot, cork, punk, York-spot, fruit-pit, bitter-pit, crinkle, and Shikkwaluo (Japanese) have been applied to identical or related troubles, all of which are characterized by malformations in the fruit or the development of large, firm, corky areas in the flesh. (Figs. 8 and 9.) They seem to be due to sudden and severe drought and to be associated with intense sunlight and often with shallow, open, or otherwise peculiar soils. Badly affected fruit is

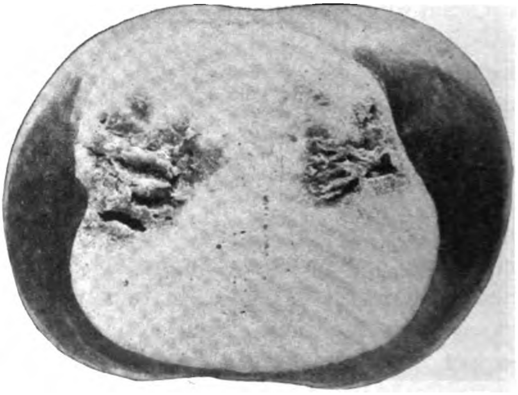

Fig. 8.—York Imperial apple, showing pockets of cork produced by drought and heat.

always discarded at picking time, but apples that are only slightly malformed or have but a small proportion of cork sometimes get into storage packages. Such fruit seems to have almost as long a storage life as normal apples, but the drought defects always detract from the market value of the fruit.

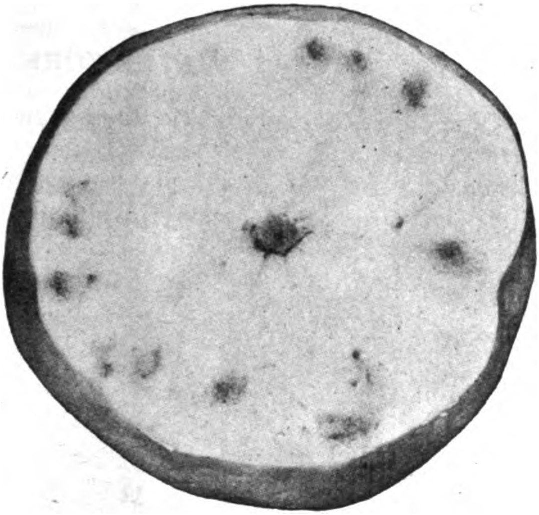

FIG. 9.—York Imperial apple with a common form of drought-spot, or cork.

STIGMONOSE.

Stigmonose is a term used to refer to spots and other malformations resulting from the healing over of insect punctures. In some cases there is a distinct depression on the surface, a considerable layer of hard tissue beneath, and a definite puncture mark, but more often there is merely a brown, corky spot or collection of spots just beneath the skin that bears a close resemblance to bitter-pit. (Fig. 10.) The corky tissue, however, is usually firmer and occurs in larger masses than in the case of bitter-pit, and the spots are fewer in number and not associated with the conducting tissue or confined to the blossom half of the apple. It is obvious that the control of stigmonose is to be effected by the control of the insects causing the injuries.

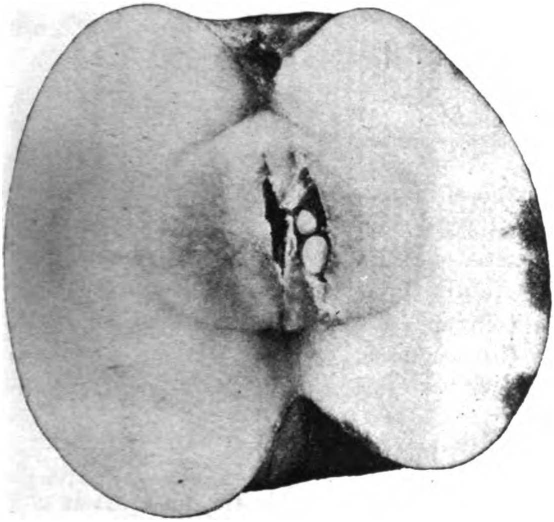

FIG. 10.—Stigmonose on a Cullen Longkeeper apple.

Stigmonose has little, if any, effect upon the storage life of the apples and is to be discriminated against on account of the inferiority of the fruit rather than because of its keeping quality.

WATER-CORE.

Water-core is a nonparasitic disease characterized by a glassy or watery appearance of the flesh. It is somewhat more common in the region of the main vasculars and the core, but may occur in any part of the apple or may involve the whole of it. (Fig. 11.) The affected tissue has a water-soaked appearance and is usually very hard. Water-core apples have a high specific gravity and can be distinguished from normal apples, when the disease is not evident on the surface, by the fact that they sink to a greater depth when placed in water. Tompkins King, Fall Pippin, Yellow Transparent, Early Harvest, Rambo, and Winesap are among the more susceptible varieties of apples.

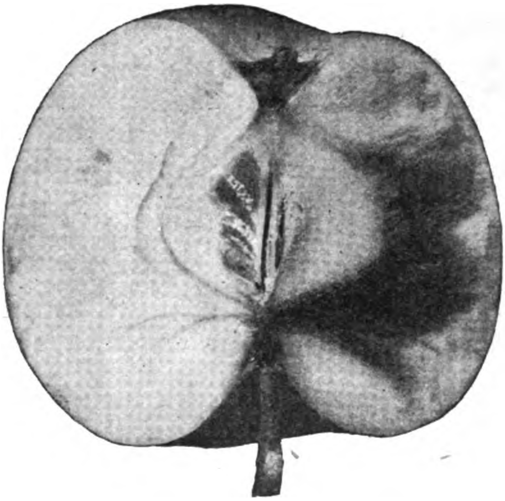

FIG. 11.—Water-core on a Jonathan apple.

Water-core is particularly bad in regions of intense sunlight and abundant moisture, and its occurrence is apparently determined by growth conditions in the orchard. Some have thought that the disease may develop in storage, but this conclusion is probably the result of overlooking affected apples at packing time. On the contrary, it has been found that in mild cases of water-core the disease may largely disappear in storage. Badly water-cored apples, however, are likely to break down early in storage.

BITTER-ROT.

Bitter-rot is a disease caused by a parasitic fungus.[1] It is of the greatest importance as an orchard disease and can be controlled by applying Bordeaux mixture as directed in the spray schedules for southern orchards, accompanied in severe cases by the pruning out of cankers. It is a serious disease in sections of Arkansas, Missouri,

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[1] *Glomerella cingulata* (Stonem.) S. and V. S.

Virginia, and other Southern States, but is of rare occurrence in northern orchards.

The larger rots naturally attract most attention. They are brown or black in color, slightly sunken, with a circular outline and clear-cut margin. With rots a half inch or more in diameter numerous small black pustules are usually evident beneath the skin or just breaking through it. (Fig. 12.) They are often arranged in a circle and when matured have pink spore masses at their tips. The affected tissue beneath is usually cone shaped. It is softer than that of black-rot but much firmer than the rot of blue mold. The tissue adjacent to the rot is often somewhat bitter.

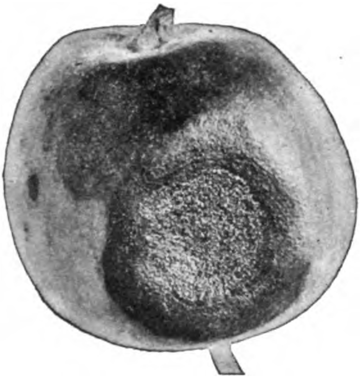

FIG. 12.—Late stage of bitter-rot on a Jonathan apple.

Another type of bitter-rot, while less common, is of greater importance in storage than the one described above. It is the late infections that appear at picking time as red or purplish spots or specks, with a darker center. (Fig. 13.) They resemble fruit spots, but the center of the spot and the tissue beneath are a solid color instead of being speckled with black or brown. These bitter-rot specks also have an entirely different storage history from fruit spots. Their development has apparently been checked by cool weather before harvest, and in some cases they are incapable of further harm, but as the fruit matures in transit or storage the larger spots may again resume activity. They will make a very active growth at 60° and a very slow development at 50° F., but are entirely inhibited at lower temperatures. After several months in storage at 32° F. these rot specks will develop rapidly upon removal of the fruit to room temperature.

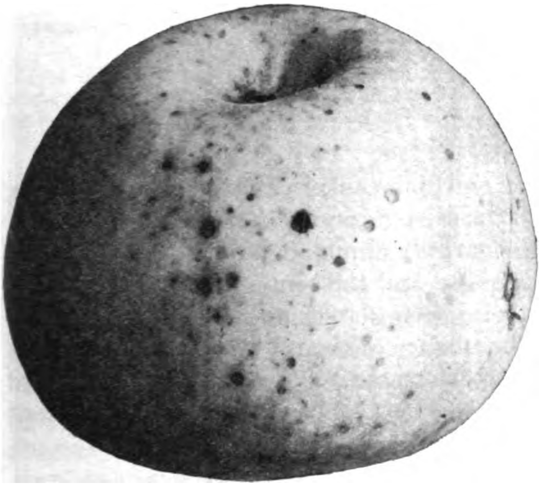

FIG. 13.—Bitter-rot spots or specks on a Ben Davis apple. Such spots make no development in cold storage, but may resume growth upon removal.

The behavior of bitter-rot at different temperatures is shown in figure 14. It is a hot-weather disease, causing extreme losses in the fall markets and also in delayed shipments and in common storage, sometimes destroying apparently sound fruit from a badly infected orchard within a few days. These losses can be entirely prevented by holding the apples at cold-storage temperatures and can be practically eliminated by cooling to 50° F.

NORTHWESTERN ANTHRACNOSE.

Anthracnose[1] is a parasitic orchard and storage disease confined to apples from the more humid sections of the Pacific Northwest. Spraying the fruit during late summer before the fall rains reduces the amount of disease developed in storage, but unless orchard control is established by cutting out limb cankers and giving the trees a fall application of strong Bordeaux mixture after the fruit is harvested, the disease can not be entirely eliminated.

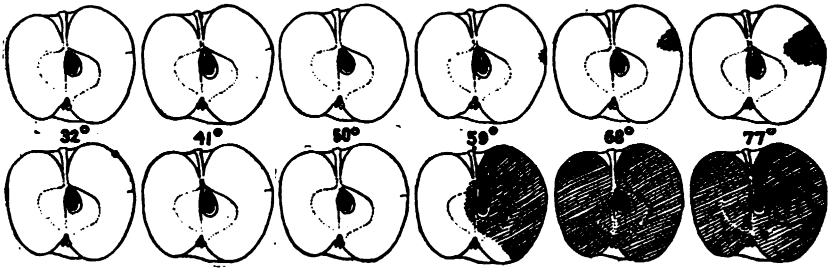

FIG. 14.—Growth of bitter-rot on apples at different temperatures. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 77° F. The heavy shading indicates the development of rot.

The rot is light brown in color and the center of the rot often a lighter brown than the margin, giving a somewhat zoned or bird's-eye effect. In later stages the surface of the rot may be spotted with pustules which emit creamy spore masses. The surface is depressed and the flesh beneath dry and leathery. The disease is most serious when there are early fall rains or when picking is delayed on account of weather conditions. The rot will continue to develop in storage, and apples from trees affected with anthracnose, although free from rot at picking time, may later become badly diseased in either common or cold storage. In the fall of 1918 apparently sound Salome apples from a tree affected with anthracnose were held in storage at various temperatures. After seven weeks the apples at 50° F. had an average of 49 rotten spots each, those at 41° F. 11 rots to the apple, while those at 32° F. were still apparently free from rot. At the end of 18 weeks the apples at 50° and 41° F. were entirely rotten and those at 32° F. had developed an average of six rots to the apple and had about one-fourth of the flesh decayed. The effect of temperature upon the rate of development of anthracnose is shown more in detail in figure 15. It is evident that while cold-storage temperatures will greatly delay the rot, apples which have had extreme exposure to the disease in the orchard are unsafe for late holdings in storage.

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[1] *Neofabraea malicorticis* (Cordley) Jackson.

BLACK-ROT.

Black-rot[1] is a parasitic disease that is of general occurrence on apples of the Atlantic Coast and Middle Western States, but seldom, if ever, occurs in the Rocky Mountain districts or the regions west of them. It is worse on summer and fall varieties. The disease can be largely controlled in the orchard by cutting out the limb cankers and following the prescribed spray schedules.

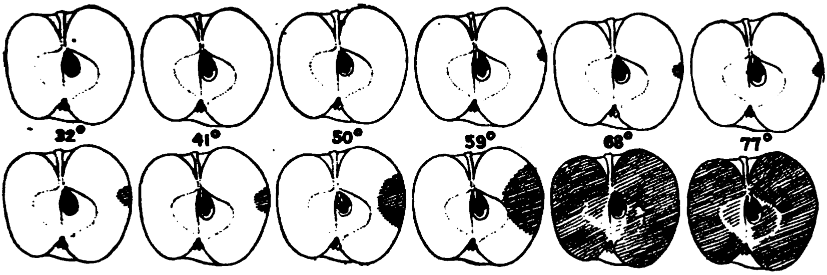

FIG. 15.—Growth of anthracnose on apples at different temperatures. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 72° F. The heavy shading indicates the development of rot.

Black-rot is one of the darkest colored rots that affect the apple. The diseased areas are usually dark brown or black and often have a decidedly zoned appearance. As the rot enlarges, small black pustules may appear on the surface, but these are not arranged in zones, as is typically the case with bitter-rot. As the rot occurs in storage, the zoning is less pronounced and the pustules usually lacking. The affected flesh of black-rot is dark brown and quite firm, in striking contrast to the soft light-brown rot produced by blue mold. Black-rot usually makes its start at an insect sting or other puncture or at the calyx where injury has resulted from frost or spray, and it sometimes develops as a core rot. (Fig. 16.) It is primarily a rot of ripe fruit, but may often be found as spots one-eighth to one-half of an inch in diameter several weeks before picking time. These develop very slowly and may even appear to be entirely dormant for a time, but later become quite active as the fruit matures.

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[1] *Sphaeropsis malorum* Pk.

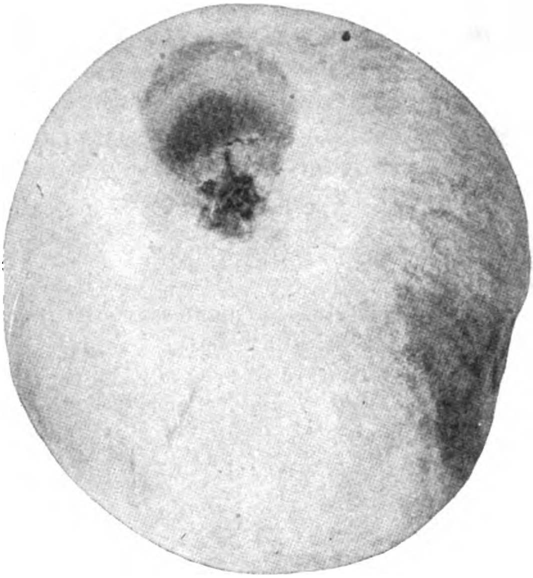

Fig. 16.—Black-rot developing at the calyx on a Ben Davis apple.

Black-rot continues to grow slowly in cold storage, but it seldom spreads from one apple to another. It makes its development almost entirely at punctures or bruises or from specklike rots that were overlooked at packing time. Figure 17 shows a Grimes apple affected with Sphaeropsis spots that are too small to seem like rots, yet in a storage test the largest of these spots made a rapid and significant growth. At 68° F. such apples were practically rotted in two weeks, at 59° in four weeks, and at 32° the spots were half an inch in diameter by the end of six weeks.

The temperature relations of black-rot are shown in figure 18.

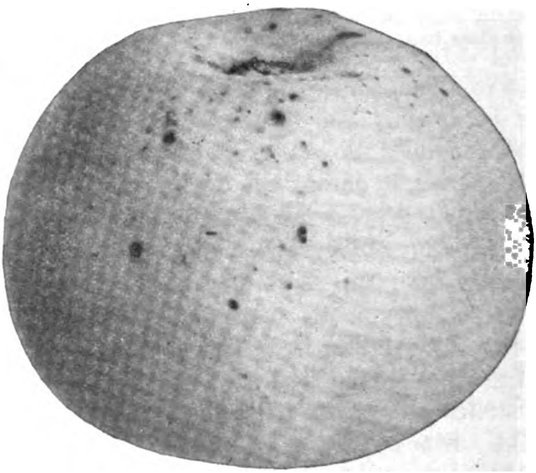

Fig. 17.—Black-rot spots on a Grimes apple. Such spots may remain dormant for a time but resume growth as the fruit matures.

ALTERNARIA ROT.

This disease is caused by one or more species of Alternaria. It is of frequent occurrence on fruit in all sections of the United States and particularly common on apples in the irrigated sections of the West. The Alternaria fungus is the most common cause of core rots, its entrance apparently being favored by the open calyx that frequently characterizes the apples from irrigated orchards. (Fig. 19.) It is the most common cause of the rots that follow Jonathan spot and York skin crack and is also common following scald.

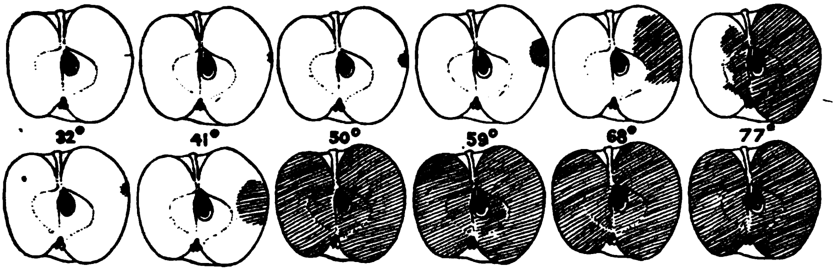

Fig. 18.—Growth of black-rot on apples in storage. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 77° F. The heavy shading shows the development of rot.

Alternaria rot looks so much like black-rot that it is sometimes impossible to distinguish one from the other by growth characteristics. In such cases a distinction can be readily made by resorting to the microscope or to laboratory cultures of the fungus. Alternaria rot, however, is seldom zoned and is often more superficial than black-rot, spreading over the surface without extending deep into the tissues.

The development of Alternaria rot is greatly delayed by cold and also by greenness and firmness in the fruit, but it will finally destroy weak and overripe apples at commercial storage temperatures.

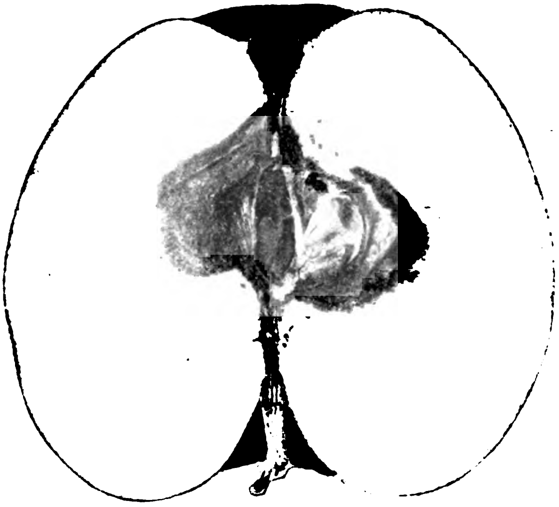

Fig. 19.—Alternaria core-rot on a Stayman Winesap apple.

BLUE MOLD.

Blue mold[1] is a fungous disease confined almost entirely to storage fruit. It is of general occurrence and by far the most destructive of all the storage rots, probably causing from 80 to 95 per cent of the total rot on stored apples. The affected tissue is quite soft, and the disease is therefore often referred to as soft-rot. The rot is light brown in color and has a very characteristic musty odor and taste. When the rot is well advanced, powdery blue-green tufts develop on the surface, giving off countless numbers of spores, each capable of producing a new rot. (Fig. 20.)

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[1] *Penicillium expansum* Link.

The germ tubes of blue-mold spores are unable to penetrate the sound skin of the apple and must rely upon wounds as points of infection. Stem punctures are one of the most common causes of rot, but finger-nail scratches by the pickers, insect injuries, scab spots, and bad bruises and punctures of all kinds may furnish a starting point for the fungus. The disease may spread from one apple to another in storage either by the scattering of the spores or by actual contact of the fruit. When a sound apple is smothered in the remains of a rotten one, the fungus is apparently able to penetrate the skin without the aid of a puncture.

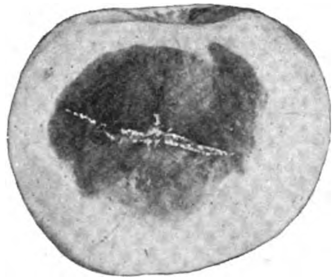

FIG. 20.—Blue-mold rot on a Newtown Pippin apple.

While blue mold is primarily a storage disease, in some of the irrigated sections of the Northwest it sometimes gains entrance at insect stings and rots the apples while still on the tree, but this condition is very exceptional. It is mainly a rot of ripe apples, and overripe fruit is particularly susceptible.

Low temperatures greatly delay the development of blue mold, especially on fruit that is not overripe at the time of storage. Cold has a much greater inhibiting effect upon the starting of rots than it has upon their development. Rots that have been allowed to get started while the apples were still warm develop rather rapidly even at cold-storage temperatures. Figure 21 shows the rate of development of blue mold at different temperatures.

The losses from the disease are enormous, but can be largely prevented by careful picking and handling, guarding against finger-nail punctures, basket scratches, barrel bruises, and stem-puncture injury, and by cooling the apples to 32° F. within a day or two after picking. The spread of blue mold in the package is decreased by wrapping the apples, thereby confining the spores and eliminating the direct contact between diseased and sound apples.

PINK-ROT.

Pink-rot[1] is entirely a storage disease. It has sometimes caused heavy storage losses in New York and other Northern States, but is not of economic importance in most fruit sections. The rot is seldom serious except as following scab, beginning its development at the margin of the scab spot. The affected tissue is firm, corky, dry, and has a very bitter taste. In the later stages of the disease the fungus may be found fruiting on the surface, giving the rot a powdery pink appearance that is the basis for the name of the disease. Pink-rot grows slowly, especially in cold storage, but may finally destroy the fruit, even at a temperature of 32° F.

---

[1] *Cephalothecium roseum* (Fries) Cda.

SPONGY DRY-ROT.

Spongy dry-rot[1] is a parasitic disease that makes its start in the orchard. It has been reported as causing considerable loss in North Carolina, New York, and other States of the Atlantic coast. It resembles black-rot, but the spots are more sunken, the texture of the tissue firmer and drier, and the color more uniformly black throughout. The surface may be roughened by the pustules of fruiting bodies. The rot is apparently unable to penetrate the sound skin. It is greatly delayed by low temperatures and has never been reported as causing severe losses in cold storage.

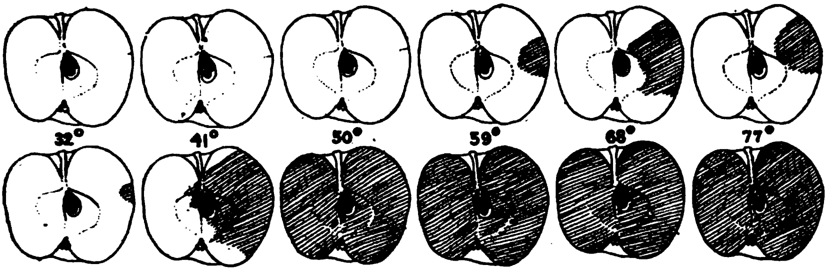

Fig. 21.—Growth of blue mold on apples in storage. The upper series shows the size of the rots at the end of two weeks after inoculation and the lower series the size at the end of eight weeks, the tempratures ranging from 32° to 77° F. The heavy shading shows the development of rot.

BROWN-ROT.

Brown-rot[2] is a parasitic disease of apples in market and storage that occasionally causes considerable loss in the Atlantic Coast and Middle Western States and in the humid sections of the Pacific Northwest, the greatest damage usually occurring on the summer and fall varieties. It closely resembles black-rot, but may be distinguished from it by its velvety appearance. Brown-rot is greatly delayed by low temperatures, yet is less retarded by cold storage than any of the rots previously mentioned.

---

[1] *Volutella fructi* Stevens and Hall.

[2] *Sclerotinia cinerea* (Bon.) Schrot.

GRAY MOLD.

Gray mold[1] is a parasitic storage disease that occasionally causes considerable loss. Its appearance is much like that of blue mold, but it is somewhat firmer and has a distinctly sour taste that is in marked contrast to the musty odor and taste of the former. Its spread from one apple to another is by contact rather than by a scattering of spores. It is greatly delayed by cold but will finally destroy infected apples even at cold-storage temperatures.

INTERNAL BREAKDOWN.

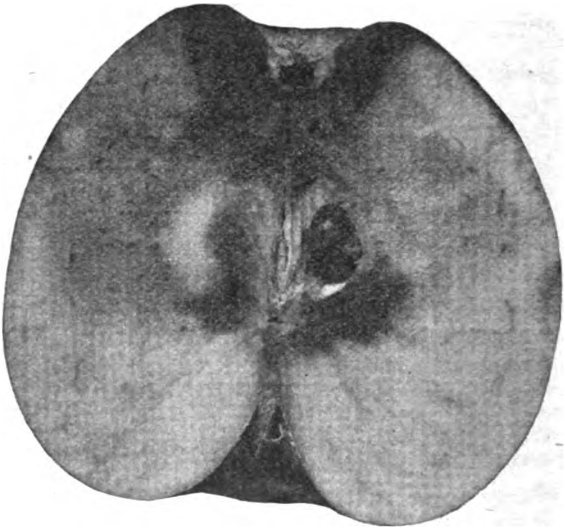

FIG. 22.—Internal breakdown of a Stayman Winesap apple.

Internal breakdown is a nonparasitic disease associated with large and overripe apples. It occurs on apples from the various fruit sections of the United States and has been reported from Australia under the name of "sleepiness." It occurs on practically all varieties, but is most serious on the summer and early-fall apples. It is characterized by a breaking down and browning of the interior of the apple. (Fig. 22.) The riper side of the apple is often more seriously affected than the greener side and the blossom half worse affected than the stem half. During the earlier stages, the flesh may be found quite moist, but it later becomes spongy and rather dry and "mealy." The skin usually retains its normal appearance, but is sometimes slightly duller and darker and in the later stages of the disease frequently cracks outward. The presence of the disease can usually be detected by the spongy softness of the apple.

Internal breakdown is particularly common on overmature apples and on those that have been forced late in the season. It may appear at picking time, but is largely a storage disease. It is a condition that characterizes the end of the life of the apple, but when it appears prematurely may be regarded as a definite disease. Delay in the packing house or in transit may be responsible for its appearance later in storage or upon removal. In commercial-storage experiments with Stayman Winesap apples it was found that internal breakdown was greatly decreased by the use of ventilated barrels and by storing in ventilated rooms. The disease is particularly serious in common storage, but fruit with a decided tendency to the disease can not be relied upon for late keeping even in cold storage.

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[1] *Botrytis* sp.

FROST INJURY.

The freezing of apples in transit or in storage results in such a variety of effects that it is difficult to give a definite characterization. Frost injury bears a close resemblance to internal breakdown, but the internal browning that results from freezing often extends to the surface of the apple, the affected tissue is more watery, and the conducting vessels usually show up prominently as dark-brown strands extending through the flesh. Unlike internal breakdown, frost injury may appear on any part of the apple and on the small green fruit as well as that which is overripe.

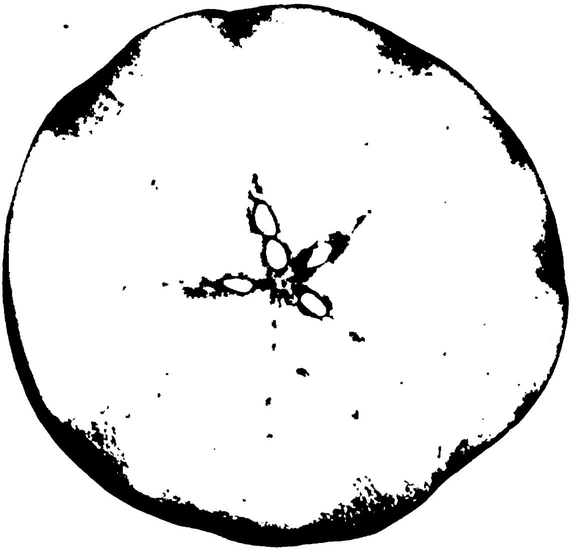

FIG. 23.—Injury on a Stayman Winesap apple resulting from bruises while frozen.

Apples will stand a temperature several degrees below 32° F. without freezing, but reach their limit for cold resistance at about 28° F. Some varieties are touched with frost at this temperature, while others remain free from it. Slightly frozen apples can be thawed out at a temperature of 32° F. or slightly above without showing injury. Their quality, however, is not as good as before the freezing. Apples are greatly damaged by any bruises made while they are frozen, and if frosted apples are to be saved, great care must be taken in handling the packages. (Fig. 23.) Apples that have been badly frozen or that have had repeated light freezes usually show frost injury, regardless of the methods of thawing.

SOFT-SCALD.

Soft-scald is a nonparasitic disease that is particularly common on the Jonathan and Rome Beauty varieties. In Australia it is known as Jonathan scald. It produces sunken blisterlike effects that extend over the apple in peculiar patterns. (Fig. 24.) Before exposure to the warm air the diseased spots on red fruit surfaces may have a whitish or pink color and the flesh beneath also be pink, the effects apparently being produced by a spread of coloring matter from the skin into the flesh. After exposure to warm air the scalded area and the flesh beneath become light brown in color. The affected tissue is very soft and the line of demarcation between it and the healthy tissue is extremely sharp. The disease resembles certain types of frost injury rather closely, and damages have frequently been paid for frost when the trouble was really soft-scald. Frost injury, however, seldom shows the clear-cut margin and the soft, light-brown flesh that characterize soft-scald. Secondary fungous infections sometimes follow soft-scald, spotting the brown area with black.

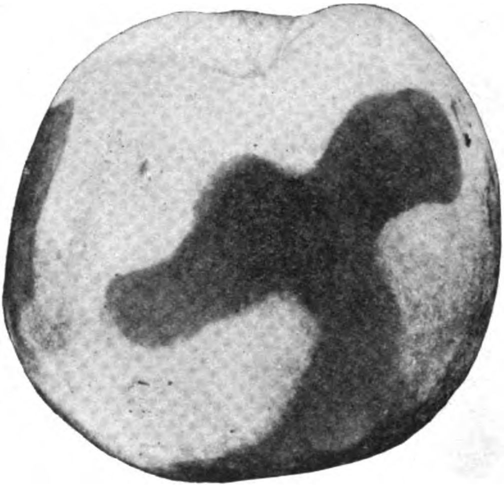
FIG. 24.—Soft-scald on a Jonathan apple.

The location of the disease on the apple appears to be determined by the points of contact with the package and with other apples, and there seems to be a close correlation between the deposition of moisture films and the occurrence of the disease.

Soft-scald is evidently due to products given off by the apples themselves, among which water and carbon dioxid appear to be important. It can be produced by inclosing apples for a few days in an air-tight jar at living-room temperature. In commercial practice it is greatly increased by delayed storage, and in fact in all instances of soft-scald of which the writers have been able to trace the history it has been found that the damaged fruit was delayed in packing houses or in transit. In the fall of 1919 the effect of delayed storage upon soft-scald was demonstrated experimentally. All of the apples were packed in barrels the day they were picked, and some of the barrels were stored the same day at 32° F. The remainder were held in a shed at a temperature of about 75° F. for one week and then placed in the same storage room. The following results were obtained after the fruit had remained in storage till January 15, 1920:

Relation of delayed storage to soft-scald on Jonathan apples.

		Soft-scald.
Immediate storage:		
Commercial barrels	per cent	0
Ventilated barrels	do	0
Delayed storage:		
Commercial barrels	do	52
Ventilated barrels	do	28

These results give striking evidence of the important part that poor ventilation and delayed storage may play in the production of this disease.

SCALD.

Scald is a transportation and storage disease that is produced by the gases given off by the apples themselves. Under the prevailing methods of handling fruit it causes greater losses than all other storage diseases combined. It is particularly serious on the York Imperial, Grimes, Arkansas (*Mammoth Black Twig*), Rome Beauty, Rhode Island Greening, Stayman Winesap, Wagener, and Baldwin varieties, and it occurs at times on almost every variety of apple.

Scald can be distinguished from all other apple diseases by its preference for the greener side of the apple. In mild cases of the disease the apple is merely tinted with brown (see title-page illustration), but in more severe cases the entire skin layer is killed and sometimes broken down to the extent that it will slough off readily from the flesh. In some instances the flesh becomes dead and brown to a depth of half an inch, and the disease takes on the appearance of an apple rot; but true rot usually spreads down into the flesh in more or less conical shape, while scald is usually diffuse, spreading over a large area without having much depth. An apple that has had its skin killed by scald becomes the ready prey of the various rot organisms, and they soon finish the work of destruction that the scald has begun.

It is a rather generally accepted idea that scald is due to the warming of the fruit after it has been removed from cold storage. This idea comes from an erroneous interpretation of very familiar facts, and this misconception in regard to the nature of scald has often resulted in throwing the responsibility for its occurrence upon the wrong party. It is true that apples usually show but little scald while held continuously in cold storage and also true that fruit apparently free from disease may become badly scalded after exposure to warm air for a few days, but the apples were already potentially scalded while still in storage and merely required the open air and the higher temperatures to allow their death processes to be completed. The real cause of scald is to be found in the accumulation of certain gases given off by the apples themselves, and prevention can be had by removing these gases by ventilation or by absorbing them with oils. There are a great many fats and oils that will accomplish this result, but the mineral oils sold under various trade names and refined so as to be practically or entirely free from odor and taste, have been found the most satisfactory. They are among the cheapest oils, they do not become rancid, and they are already extensively used on paper and otherwise in connection with food products. The most convenient method of applying the oil is by means of oiled wrappers. The development of scald is much more rapid at high than at low temperatures. Most varieties of apples are scalded as badly at 60° F. in one month as at 40° F. in three months. (Fig. 25.)

The responsibility for scald does not always lie in the same quarter. Its occurrence is influenced by orchard, packing-house, and transportation as well as storage conditions. Large apples and those that have been forced late in the season by heavy irrigation or rains have an increased susceptibility to scald. Apples that have been scarred and russeted by powdery mildew are rendered more susceptible, while those from trees that have been badly affected with cedar rust are very resistant to scald. Fruit that is picked green is much more susceptible than that which is left on the trees till well matured. The holding of apples in closed packing sheds or in unrefrigerated cars may be responsible for the development of scald later in storage or upon removal from storage. Placing large quantities of warm fruit in a particular storage room instead of distributing it in several rooms is likely to result in delayed cooling and in heavy losses from scald.

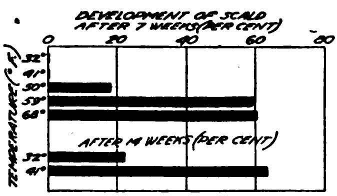

FIG. 25.—Effect of temperature on the development of scald on Grimes apples. The upper part of the figure shows the percentage of scald at the various temperatures at the end of 7 weeks; the lower part the percentage of scald at the lower temperatures at the end of 14 weeks. At this time no apples were left at the higher temperatures.

Apples scald far less in boxes, crates, or ventilated barrels (barrels with 15 holes three-fourths by 4 inches cut in the staves) than in the usual commercial barrels, especially if the storage room is allowed considerable change of air. They scald far less when located near the door of the storage room than when in the back corners away from the aisles. False floors, wall spaces, openings between the stacks, the operation of fans, and the throwing open of storage windows when the outside temperature will allow, all contribute to scald prevention.

Scald can be entirely prevented by storing apples in oiled (not waxed) wrappers. (Fig. 26.) This treatment has been found completely successful even when susceptible varieties have been placed in unventilated storage and held far beyond their usual storage season. A good quality of oiled wrapper can be prepared by hand-oiling the usual commercial wrapper, but the cost of the labor is too great. The oiled paper now on the market has been prepared for other purposes and is too heavy for convenient use on apples. Lighter weight oiled papers suitable for use as apple wrappers are now in process of preparation.

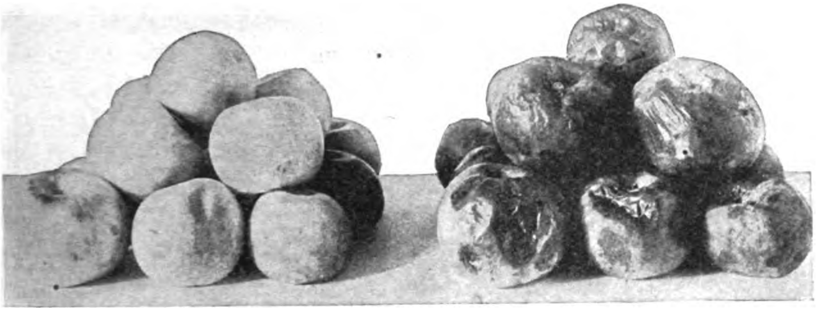

FIG. 26.—Effect of oiled wrappers in scald prevention. These York Imperial apples were removed from cold storage on March 5 and photographed on March 15. Those on the left were wrapped in oiled wrappers; those on the right were unwrapped. At the time of removal from storage the two lots looked alike, but three days later the unwrapped apples were badly scalded, and at the end of 10 days they were almost entirely rotten, as shown in the illustration. The apples that had been held in oiled wrappers while in storage were still sound after three weeks in a warm laboratory.

THE STORAGE LIFE OF APPLES.

It is generally recognized that each variety of apple has its own storage limitations and that the keeping quality of the fruit varies from year to year. Dealers plan to dispose of their apples while they are still in good condition, and if it is found necessary to hold them till they are near the end of their storage life a close watch is usually kept to see that their limit is not exceeded. In spite of these precautions large quantities of apples fall prey to rots and scald instead of serving their purpose as food. This loss is not all sustained by the dealer, but may be passed along to the retailer and finally to the consumer. The relation of supply and demand and the behavior of the markets are sometimes responsible for fruit being held too late, but much of the loss on stored fruit is due to misjudgment in regard to its storage life, abuses that destroy its protective skin layer, and faulty shipping and storage conditions.

Fruit-spot, stigmonose, and even small blotch specks usually have little effect upon the storage life of the fruit, but scab, black-rot, and bitter-rot specks may greatly shorten its life. Apples from trees affected by anthracnose and those showing a tendency to bitter-pit will probably become diseased even in cold storage. Coarse overgrown apples and apples that are forced late in the season can never be relied upon for late keeping. The sound skin of the apple forms an almost complete protection from storage rots, but punctures and scratches pave the way for early decay. When fruit is placed in cold storage immediately upon picking, the rots develop slowly, but if the rot organisms can have a week's start on the warm fruit they will make a rather rapid growth even at 32° F. Scald is the most deceptive of all the storage troubles. Apples may become badly scalded while in storage, yet appear entirely healthy until exposed to warmer air. This peculiarity of the disease has often resulted in heavy losses and serious misunderstandings in connection with after-storage shipments of fruit, and it has served as a great handicap in the distribution of apples to smaller centers. The time of the appearance and the severity of scald may be somewhat influenced by the growth conditions in the orchard, but they are largely determined by the ventilation and cooling which the fruit receives after it has been packed.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1160

DISEASES of APPLES IN STORAGE

GIF

STORAGE DISEASES take a heavy annual toll on the harvested crop of apples, greatly reducing an important food supply and increasing the cost and uncertainty of market operations.

The responsibility for this loss may lie with the orchardist, the transportation company, the dealer, or the storage management.

Delay in warm packing sheds or cars shortens the natural life of apples and greatly increases their tendency to rots and scald. Filling the storage rooms so rapidly that cold-storage temperatures can not be maintained has a similar bad effect.

Apple rots are slow to start at a temperature of 32° F., but if a beginning has been made at a higher temperature they can proceed much more rapidly.

In cases of unavoidable delay in cooling, the losses from scald can be greatly reduced by good ventilation. Apples scald far less when in boxes, baskets, or ventilated barrels than in the usual tight barrel. Green fruit is much more susceptible to scald than that which is well matured. Wrapping apples in oiled wrappers or packing them in shredded oiled paper furnishes the most complete protection against scald.

Washington, D. C.

Issued September 1920
Revised October 1930
Slightly revised May 1935

DISEASES OF APPLES IN STORAGE

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PRINCIPLES GOVERNING DISEASE CONTROL

THE diseases that appear on apples in storage and upon their removal may be the result of storage conditions, or their occurrence may have been predetermined by orchard and transportation conditions. They may be due to the work of a parasite or to the direct action of unfavorable conditions upon the fruit itself. Diseases like scab and certain rots that are definitely traceable to the action of particular fungi are called parasitic diseases, while bitter pit, water core, and scald are known to be due wholly to abnormal physiological conditions in the fruit itself and are called nonparasitic or physiological diseases. Both parasitic and nonparasitic diseases can be prevented largely by proper methods of growing and handling the fruit, but each disease has its own peculiar laws of behavior upon which the requirements for its control must be based.

SCAB

Scab[1] is a parasitic disease and mainly an orchard disease. It can be largely controlled by carrying out the spraying schedules that have been developed and recommended for the different fruit sections. It is particularly serious in the orchards of the northeastern United States and in those of the humid sections of the Pacific Northwest, but it also occurs at the higher altitudes as far south as Virginia, North Carolina, and Arkansas.

Scab may appear on the picked fruit as large corky or dark sooty spots with a light-gray margin, or as small sooty spots or specks often irregular in outline and usually without the gray margin.

---

[1] *Venturia inaequalis* (Cke.) Wint.

(Fig. 1.) The latter form of the disease is the one that is most likely to pass into storage packages. With both the large and the small spots the protecting skin is broken and the apple exposed to early destruction by the rot organisms. Pink rot and blue mold are among the most common decays that follow scab.

Scab sometimes continues to develop in storage, but the characteristics of the spots are quite different from those found at picking time. They are smooth, black, and sunken, sometimes attaining a diameter of one-fourth of an inch before the fungus breaks through to the surface or causes any roughening of the skin. The development of the scab fungus is checked by low temperatures, and scab ordinarily makes little trouble in cold storage except as a source of rot infections; yet a late spread of the disease in the orchard is sometimes followed by a serious development in storage.

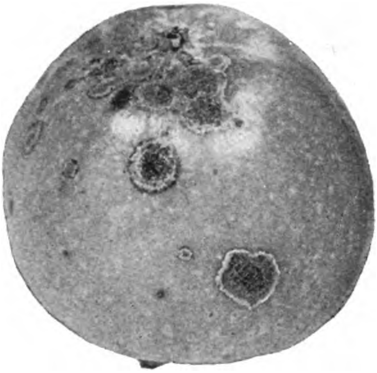

FIGURE 1.—Scab as it appears at picking time on a White Pearmain apple

BLOTCH

Blotch[2] is a parasitic orchard disease. It can be controlled by orchard sanitation and properly timed spray applications. It is a serious disease only in the more southern orchards of the Eastern and Middle States, but it seems to be gradually spreading northward.

Blotch appears on the fruit as hard brown or black blotches with jagged margins. The cuticle does not peel off, as with scab, but the protecting skin layers are killed and often broken by fissures and cracks. (Fig. 2.) Badly blotched apples are usually discarded or sold for immediate use, but those with a few small spots sometimes get into storage. The disease makes little if any development at cold-storage temperature, but the blotch spots may furnish a starting point for storage rots, particularly black rot and Alternaria rot.

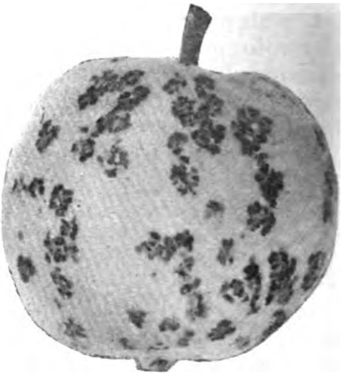

FIGURE 2.—Blotch on a Ben Davis apple

FRUIT SPOT

Fruit spot[3] is a parasitic disease that can be controlled by midsummer spraying, yet is often found in abundance on the harvested fruit. It is of common occurrence in the orchards of the Atlantic coast from Maine to North Carolina, and it also occurs in Ohio, Missouri, and Arkansas. It has also been described under the names fruit speck, New Hampshire fruit spot, and flecked spot, and is sometimes referred to as Brooks spot and included in the term Baldwin spot.

---

[2] *Phyllosticta solitaria* E. and E.

[3] *Mycosphaerella pomi* Passer.

The spots are small, seldom having a diameter of more than three-sixteenths of an inch. They are more highly colored than the normal skin, taking a deep red when on the red or blush areas and a dark green when on the green or yellow fruit surfaces. The center of the spot is usually specked or flecked with black, giving an appearance that does not occur in any other spot disease. (Fig. 3.) This flecked appearance is seen to better advantage after a very thin peel has been removed from the apple. The spots are shallow, usually affecting only the skin tissue. They may be slightly sunken, but usually at picking time have little or no corky tissue.

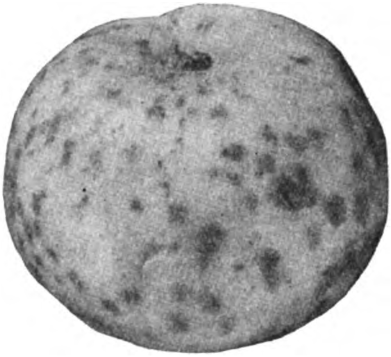

FIGURE 3.—Fruit spot on a Grimes Golden apple

In common storage the fruit spots may become more sunken and develop a shallow layer of corky tissue beneath, and the inconspicuous ones may develop so that the spots appear more numerous. If the fruit is delayed in reaching storage similar changes may occur, but when the apples are placed in cold storage immediately development is extremely slow. With fruit spot the protecting skin layer is not destroyed, and, unlike scab and blotch, the disease does not serve as a source of rot infection.

JONATHAN SPOT

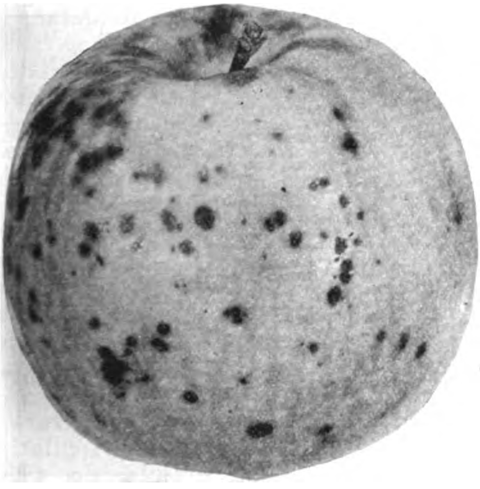

FIGURE 4.—Jonathan spot on a Jonathan apple

Jonathan spot is a nonparasitic disease and can not be controlled by spraying. It is apparently associated with a varietal weakness in the epidermal tissue of the apple. It is particularly common on Jonathan apples, but it occurs on the Stayman Winesap, Esopus Spitzenberg, Wealthy, Rome Beauty, and a number of other varieties. The disease varies with the season, but is found in all sections where susceptible varieties are grown.

Jonathan spot appears as small black or brown spots that give the apple a somewhat freckled appearance. (Fig. 4.) In the earlier and more typical stages of the disease the spots are very superficial, usually being entirely removed by the thinnest possible peel; later they may become somewhat enlarged and develop a shallow layer of corky tissue immediately beneath. Jonathan spots differ from those of either fruit spot or bitter pit in being smaller and more superficial and in having a solid brown color and a clear-cut margin.

Jonathan spot may occasionally appear on the fruit before it is picked, but the main development of the disease is after removal from the tree. In general, the highly colored apples are more likely to be affected than the greener ones, but in storage the greener apples sometimes develop a large number of spots that closely resemble a speckled scald. Large apples usually are more susceptible to the disease than smaller ones. The disease is greatly decreased by low temperatures. (Fig. 5.) Fruit held in common storage has been found badly affected with Jonathan spot at the end of 2 weeks, while similar fruit placed immediately in cold storage has been entirely free from the disease at the end of 8 weeks and practically free at the end of 14 weeks. Apples that have a tendency to Jonathan spot sometimes develop the disease very rapidly upon removal from storage. The most effective means of control is found in hastening the fruit to cold storage and in keeping it as cool as possible after removal. Jonathan spots furnish a point of infection for Alternaria and other rot organisms.

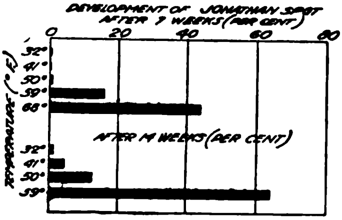

FIGURE 5.—Effect of temperature on the development of Jonathan spot on apples. The upper part of the figure shows the percentage of Jonathan spot developed at the different temperatures at the end of 7 weeks; the lower part shows the percentage developed at the end of 14 weeks. At 68° F. the apples had rotted before the second record was taken

BITTER PIT

Bitter pit is a nonparasitic disease, apparently due to derangements in soil-moisture conditions. It occurs on apples in all sections of the United States and is a serious disease in Europe, South Africa, and Australia.

Bitter pit has also been described under the names Stippen, Baldwin spot, and fruit pit. In the United States the Baldwin, Grimes Golden, Northern Spy, and Rhode Island Greening varieties are particularly susceptible to the disease.

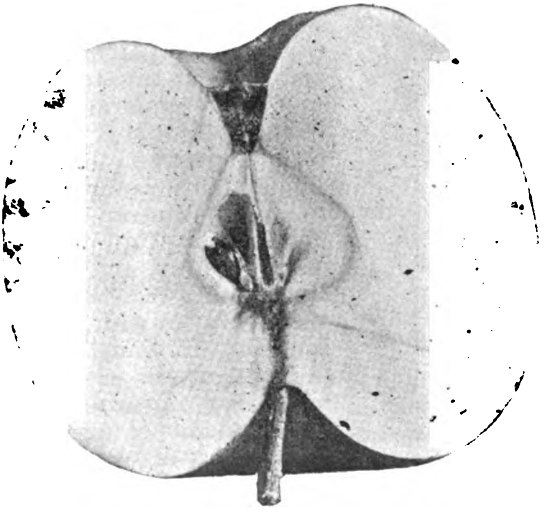

FIGURE 6.—Bitter pit on a Grimes Golden apple as seen in cross section

The disease is characterized by the development of small brown spots or streaks in the flesh of the apple, most abundant just beneath the skin. (Fig. 6.) The spots are associated with the water-conducting strands and sometimes follow this tissue deep into the flesh. The disease is usually evident on the surface of the apple as sunken, bruiselike spots that somewhat resemble hail injury. At first these spots have a water-soaked appearance, but later they may become more highly colored than the surrounding skin, taking a deep red when on a blush area and retaining a bright green when on a green or yellow fruit surface. They finally become a deep brown and are much sunken, giving the apple a badly pitted appearance. Bitter pit is confined almost entirely to the blossom half of the apple. It differs from Jonathan spot and fruit spot in this respect, and also in the fact that the spots are bruiselike, more sunken, contain more dead brown tissue, and are more deeply seated. Jonathan spots and fruit spots are usually entirely removed in peeling an apple, but the bitter-pit spots are cut into and made more evident.

Bitter pit is largely due to some overstimulation of the fruit during the latter part of the growing season. Heavy irrigation and heavy rainfall during the last weeks before picking are particularly favorable to the disease. (Fig. 7.) Cultivation, fertilizers, cover crops, pruning, thinning the fruit, and the age of the trees may all have a bearing on its occurrence. Everything that contributes to the stabilizing of the moisture conditions in the soil and to an even, normal growth of the fruit throughout the summer is of value in the prevention of the disease. Bitter pit is worse on the fruit from young trees than on that from old ones. In general, it is worse on large apples than on small ones, yet susceptibility to the disease is determined not so much by size as by the time and nature of the orchard conditions that produce the growth.

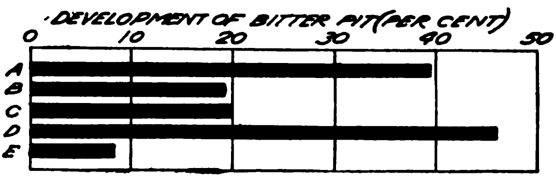

FIGURE 7.—Effects of irrigation on the development of bitter pit in storage on Grimes Golden apples from Wenatchee, Wash. *A*, Heavy irrigation throughout the season; *B*, medium irrigation throughout the season; *C*, light irrigation throughout the season; *D*, medium irrigation followed by heavy; *E*, heavy irrigation followed by light

While bitter pit is largely if not wholly due to orchard conditions, its main development is after removal of the fruit from the tree, in the packing house, in transit, or in storage. It does not spread from one apple to another in the package, but the spots already present may enlarge and others may develop either on fruit already affected or on seemingly sound apples from similar orchard conditions. The development of the disease is delayed by placing it immediately in cold storage, but fruit that shows a tendency to bitter pit at picking time is seldom suited for late keeping.

DROUGHT SPOT

The terms "drought spot," "cork," "punk," "York spot," "fruit pit," "bitter pit," "crinkle," and "Shikkwaluo" (Japanese) have been applied to identical or related troubles, all of which are characterized by malformations in the fruit or the development of large, firm, corky areas in the flesh. (Figs. 8 and 9.) They seem to be due to sudden and severe drought and to be associated with intense heat and often with shallow, open, or otherwise peculiar soils. Badly affected fruit is always discarded at picking time, but apples that are only slightly malformed or have but a small proportion of cork sometimes get into storage packages. Such fruit seems to have almost as long a storage life as normal apples, but the drought defects always detract from the market value of the fruit.

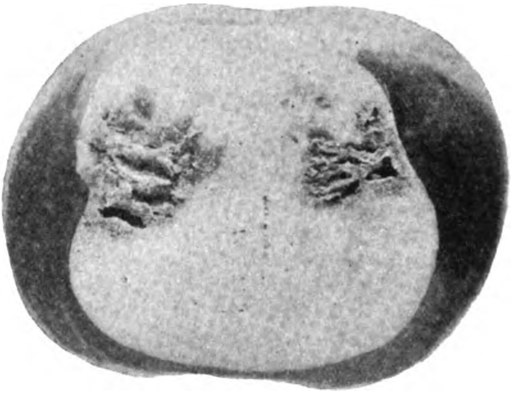

FIGURE 8.—York Imperial apple, showing pockets of cork produced by drought and heat

STIGMONOSE

Stigmonose is a term used to refer to spots and other malformations resulting from insect punctures. In some cases there is a distinct depression on the surface, a considerable layer of hard tissue beneath, and a definite puncture mark, but more often there is merely a brown, corky spot or collection of spots just beneath the skin that bears a close resemblance to bitter pit. (Fig. 10.) The corky tissue, however, is usually firmer and occurs in larger masses than in the case of bitter pit, and the spots are fewer in number and not associated with the conducting tissue or confined to the blossom half of the apple. It is obvious that the control of stigmonose is to be effected by the control of the insects causing the injuries.

Stigmonose has little if any effect upon the storage life of the apples and is to be discriminated against on account of the inferiority of the fruit rather than because of its keeping quality.

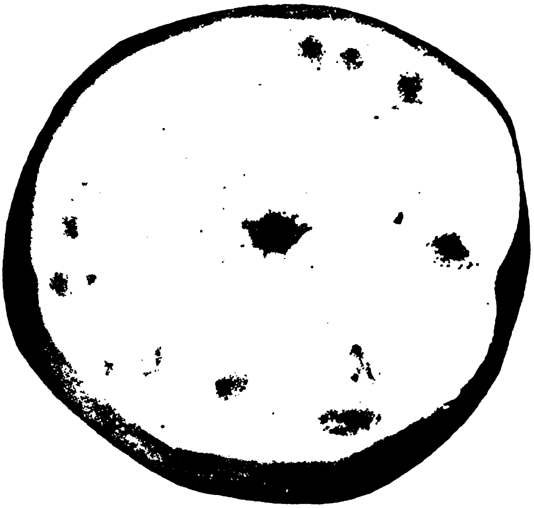

FIGURE 9.—York Imperial apple with a common form of drought spot or cork

WATER CORE

Water core is a nonparasitic disease characterized by a glassy or watery appearance of the flesh. It is somewhat more common in the region of the main vasculars and the core, but may occur in any part of the apple or may involve the whole of it. (Fig. 11.) The affected tissue has a water-soaked apppearance and is usually very hard. Tompkins King, Fall Pippin, Yellow Transparent, Early

Harvest, Rambo, and Winesap are among the more susceptible varieties of apples.

Water core is particularly bad in regions of intense heat and sunlight. High temperature at the time the apples are approaching maturity is especially favorable to the development of the disease. Sunburned apples show a strong tendency to water core. The disease often increases rapidly as the apples become overmature. Water-core apples have a high sap concentration, and the diseased condition is apparently the result of sap exudation under pressure.

Some persons have thought that the disease may develop in storage, but this conclusion is probably the result of overlooking affected apples at packing time. On the contrary, it has been found that in mild cases of water core the disease may largely disappear in storage. Badly water-cored apples, however, are likely to break down early in storage.

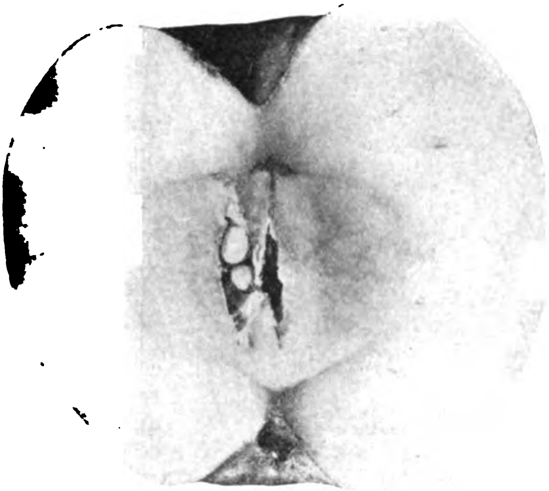

FIGURE 10.—Stigmonose on a Cullen apple

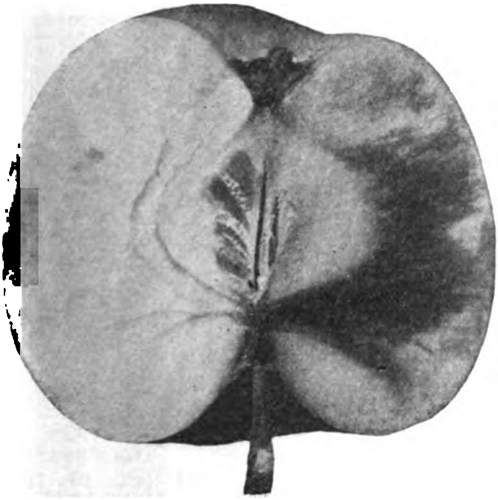

FIGURE 11.—Water core on a Jonathan apple

BITTER ROT

Bitter rot is a disease caused by a parasitic fungus.[4] It is of the greatest importance as an orchard disease and can be controlled by applying Bordeaux mixture as directed in the spray schedules for southern orchards, accompanied in severe cases by the pruning out of cankers. It is a serious disease in sections of Arkansas, Missouri, Virginia, and other Southern States, but is of rare occurrence in northern orchards.

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[4] *Glomerella cingulata* (Stonem.) S. and V. S.

The larger rots naturally attract most attention. They are brown or black in color, slightly sunken, with a circular outline and a clear-cut margin. With rots a half inch or more in diameter numerous small black pustules are usually evident beneath the skin or just breaking through it. (Fig. 12.) They are often arranged in a circle and when matured have pink spore masses at their tips. The affected tissue beneath is usually cone shaped. It is softer than that of black rot but much firmer than the rot of blue mold. The tissue adjacent to the rot is often somewhat bitter.

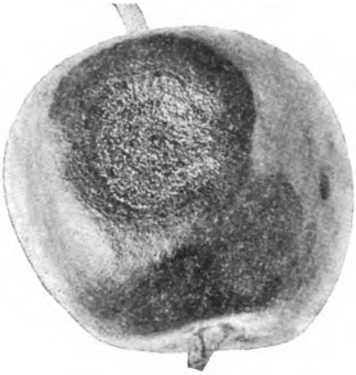

FIGURE 12.—Late stage of bitter rot on a Jonathan apple

Another type of bitter rot, while less common, is of greater importance in storage than the one described above. It is the late infections that appear at picking time as red or purplish spots or specks, with a darker center. (Fig. 13.) They resemble fruit spots, but the center of the spot and the tissue beneath are a solid color instead of being speckled with black or brown. These bitter-rot specks also have an entirely different storage history from fruit spots. Their development has apparently been checked by cool weather before harvest, and in some cases they are incapable of further harm, but as the fruit matures in transit or storage the larger spots may again resume activity. They will make a very active growth at 60° and a very slow development at 50° F., but are entirely inhibited at lower temperatures. After several months in storage at 32° these rot specks will develop rapidly upon removal of the fruit to room temperature.

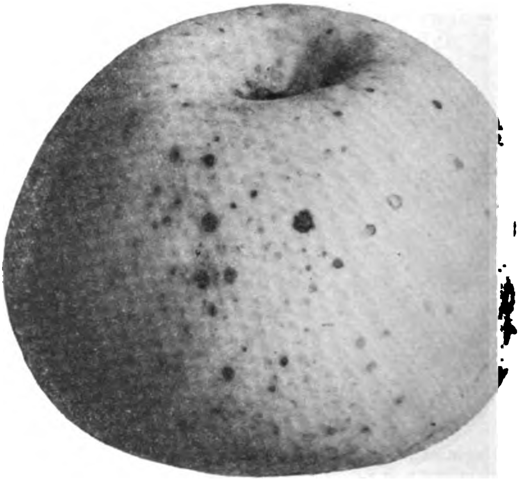

FIGURE 13.—Bitter-rot spots or specks on a Ben Davis apple. Such spots make no development in cold storage, but may resume growth upon removal

The behavior of bitter rot at different temperatures is shown in Figure 14. It is a hot-weather disease, causing extreme losses in the fall markets and also in delayed shipments and in common storage, sometimes destroying apparently sound fruit from a badly infected orchard within a few days. These losses can be entirely prevented by holding the apples at cold-storage temperatures and can be practically eliminated by cooling to 50° F.

BULL'S-EYE ROT

Bull's-eye rot is the name commonly applied to the rots produced by either northwestern anthracnose[5] or perennial canker.[6] Northwestern anthracnose has been known for a long time as a parasitic orchard and storage disease of apples in the more humid sections of the Pacific Northwest. In recent years a similar but somewhat more virulent and destructive disease has appeared in some of the irrigated sections of Oregon and Washington and has been described as perennial canker. The fruit rots produced by the two organisms are so nearly identical in appearance that it is practically impossible to tell them apart except by microscopical study, and both are included under the name bull's-eye rot.

The rot is light brown in color, and the center of the rot usually is a lighter brown than the margin, giving a zoned or bull's-eyed effect. In later stages the rot may be spotted with pustules which emit creamy spore masses. The surface of the rot is depressed, and the flesh beneath is dry and leathery. The most serious losses from bull's-eye rot occur when the fall rains begin before picking is completed. Apples from trees affected with either anthracnose or perennial canker, although free from rot at picking time, may later become badly diseased in either common or cold storage. In the fall of 1918 apparently sound Salome apples from a tree affected with anthracnose were held in storage at various temperatures. After 7 weeks the apples at 50° F. had an average of 49 rotten spots each, those at 41° had 11 rots to the apple, while those at 32° were still apparently free from rot. At the end of 18 weeks the apples at 32° had developed an average of 6 infraction centers each. The effect of temperature upon the rate of development of anthracnose is shown in more detail in Figure 15. The temperature response of the perennial canker fungus is almost identical with that of the anthracnose.

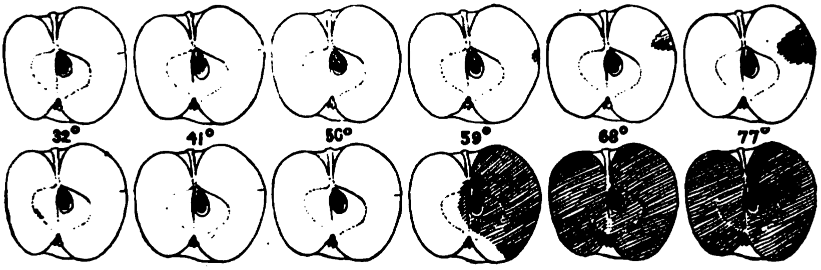

FIGURE 14.—Growth of bitter rot on apples at different temperatures. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 77° F. The heavy shading indicates the development of rot

BLACK ROT

Black rot[7] is a parasitic disease that is of general occurrence on apples of the Atlantic coast and Middle Western States, but seldom if ever occurs in the Rocky Mountain region or the areas to the west. It is worse on summer and fall varieties. The disease can be largely controlled in the orchard by cutting out the limb cankers and following the prescribed spray schedules.

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[5] *Neofabraea malicorticis* (Cordley) Jackson.
[6] *Gloeosporium perennans* Zeller and Childs.
[7] *Sphaeropsis malorum* Pk.

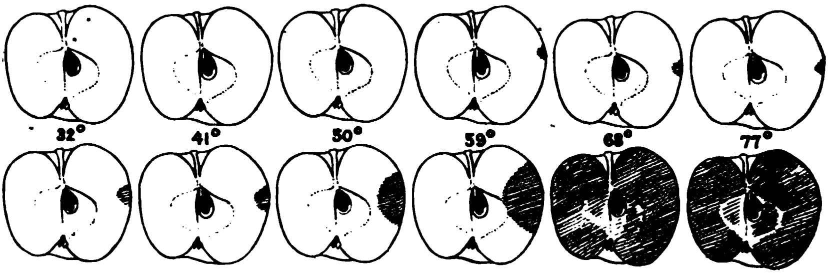

FIGURE 15.—Growth of anthracnose on apples at different temperatures. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 77° F. The heavy shading indicates the development of rot

Black rot is one of the darkest colored rots that affect the apple. The diseased areas are usually dark brown or black and often have a decidedly zoned appearance. As the rot enlarges, small black pustules may appear on the surface, but these are not arranged in zones, as is typically the case with bitter rot. As the rot occurs in storage, the zoning is less pronounced and the pustules usually lacking. The affected flesh of black rot is dark brown and quite firm, in striking contrast to the soft light-brown rot produced by blue mold. Black rot usually makes its start at an insect sting or other puncture or at the calyx where injury has resulted from frost or spray, and it sometimes develops as a core rot. (Fig. 16.) It is primarily a rot of ripe fruit, but may often be found as spots one-eighth to one-half of an inch in diameter several weeks before picking time. These develop very slowly and may even appear to be entirely dormant for a time, but later become quite active as the fruit matures.

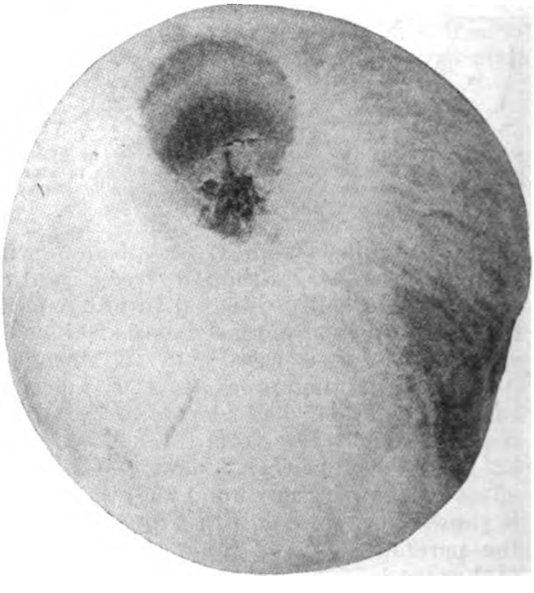

FIGURE 16.—Black rot developing at the calyx on a Ben Davis apple

Black rot continues to grow slowly in cold storage, but it seldom spreads from one apple to another. It makes its development almost entirely at punctures or bruises or from specklike rots that were overlooked at packing time. Figure 17 shows a Grimes Golden apple affected with Sphaeropsis spots that are too small to seem like rots, yet in a storage test the largest of these spots made a rapid and significant growth. At 68° F. such apples were practically rotted in two weeks, at 59° in four weeks, and at 32° the spots were half an inch in diameter by the end of six weeks.

The temperature relations of black rot are shown in Figure 18.

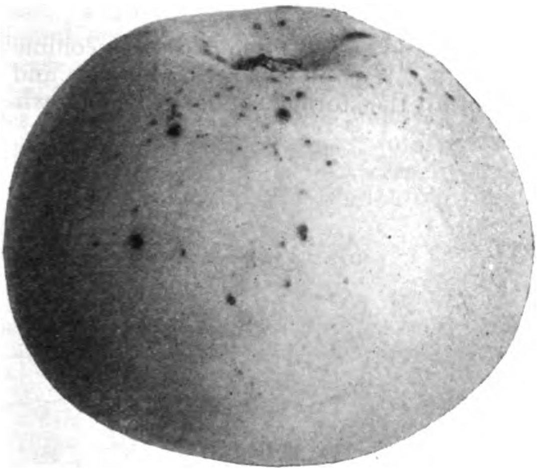

FIGURE 17.—Black-rot spots on a Grimes Golden apple. Such spots may remain dormant for a time but resume growth as the fruit matures

ALTERNARIA ROT

The disease known as Alternaria rot is caused by one or more species of the Alternaria fungus. It is of frequent occurrence on fruit in all sections of the United States and particularly common on apples in the irrigated sections of the West. The Alternaria fungus is the most common cause of core rots, its entrance apparently being favored by the open calyx that frequently characterizes the apples from irrigated orchards. (Fig. 19.) It is the most common cause of the rots that follow Jonathan spot and York skin crack and is also common following scald.

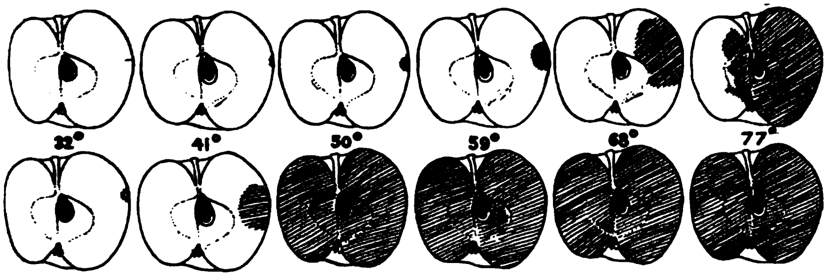

FIGURE 18.—Growth of black rot on apples in storage. The upper series shows the size of the rots after two weeks in storage and the lower series after eight weeks in storage, the temperatures ranging from 32° to 77° F. The heavy shading shows the development of rot

Alternaria rot looks so much like black rot that it is sometimes impossible to distinguish one from the other by growth characteristics. In such cases a distinction can be readily made by resorting to the microscope or to laboratory cultures of the fungus. Alternaria rot, however, is seldom zoned and is often more superficial than black rot, spreading over the surface without extending deep into the tissues.

The development of Alternaria rot is greatly delayed by cold and also by greenness and firmness in the fruit, but it will finally destroy weak and overripe apples at commercial storage temperatures.

BLUE MOLD

Blue mold[8] is a fungous disease confined almost entirely to storage fruit. It is of general occurrence and by far the most destructive of all the storage rots, probably causing 75 per cent of the total rot on stored apples. The affected tissue is quite soft, and the disease is therefore often referred to as soft rot. The rot is light brown in color and has a very characteristic musty odor and taste. When the rot is well advanced, powdery blue-green tufts develop on the surface, giving off countless numbers of spores, each capable of producing a new rot. (Fig. 20.)

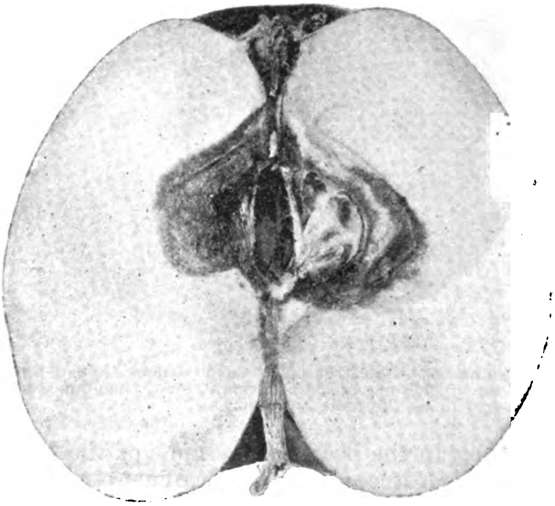

FIGURE 19.—Alternaria core rot on a Stayman Winesap apple

The germ tubes of blue-mold spores are unable to penetrate the sound skin of the apple and must rely upon wounds as points of infection. Stem punctures are one of the most common causes of rot, but finger-nail scratches by the pickers, insect injuries, scab spots, bad bruises, and punctures of any kind may furnish a starting point for the fungus. The disease may spread from one apple to another in storage either by the scattering of the spores or by actual contact of the fruit. When a sound apple is smothered in the remains of a rotten one, the fungus is apparently able to penetrate the skin without the aid of a puncture.

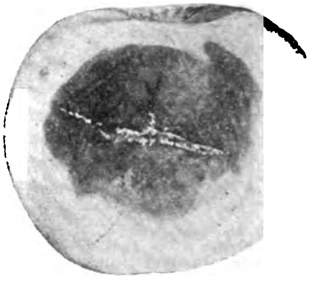

FIGURE 20.—Blue-mold rot on a Yellow Newtown apple

While blue mold is primarily a storage disease, in some of the irrigated sections of the Northwest it sometimes gains entrance at insect stings and rots the apples while still on the tree, but this condition is very exceptional. It is mainly a rot of ripe apples, and overripe fruit is particularly susceptible.

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[8] *Penicillium expansum* Link.

Low temperatures greatly delay the development of blue mold, especially on fruit that is not overripe at the time of storage. Cold has a much greater inhibiting effect upon the starting of rots than it has upon their development. Rots that have been allowed to get started while the apples were still warm develop rather rapidly even at cold-storage temperatures. Figure 21 shows the rate of development of blue mold at different temperatures.

The losses from the disease are enormous, but can be largely prevented by careful picking and handling, guarding against finger-nail punctures, basket scratches, barrel bruises, and stem-puncture injury, and by cooling the apples to 32° F. within a day or two after picking. The spread of blue mold in the package is decreased by wrapping the apples, thereby confining the spores and eliminating the direct contact between diseased and sound apples.

PINK ROT

Pink rot[9] is entirely a storage disease. It has sometimes caused heavy storage losses in New York and other Northern States, but is not of economic importance in most fruit sections. The rot is seldom serious except as following scab, beginning its development at the margin of the scab spot. The affected tissue is firm, corky, dry, and has a very bitter taste. In the later stages of the disease the fungus may be found fruiting on the surface, giving the rot a powdery pink appearance that is the basis for the name of the disease. Pink rot grows slowly, especially in cold storage, but may finally destroy the fruit, even at a temperature of 32° F.

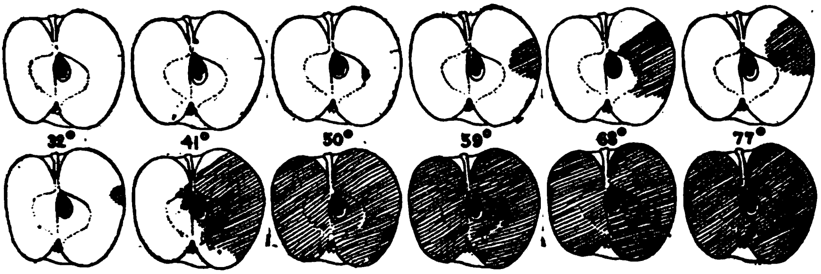

FIGURE 21.—Growth of blue mold on apples in storage. The upper series shows the size of the rots at the end of two weeks after inoculation and the lower series the size at the end of eight weeks, the temperatures ranging from 32° to 77° F. The heavy shading shows the development of rot

SPONGY DRY ROT

Spongy dry rot[10] is a parasitic disease that makes its start in the orchard. It has been reported as causing considerable loss in North Carolina, New York, and other States of the Atlantic coast. It resembles black rot, but the spots are more sunken, the texture of the tissue firmer and drier, and the color more uniformly black throughout. The surface may be roughened by the pustules of fruiting bodies. The rot is apparently unable to penetrate the sound skin. It is greatly delayed by low temperatures and has never been reported as causing severe losses in cold storage.

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[9] *Cephalothecium roseum* (Fries) Cda.
[10] *Volutella fructi* Stevens and Hall.

BROWN ROT

Brown rot[11] is a parasitic disease of apples in market and storage that occasionally causes considerable loss in the Atlantic coast and Middle Western States and in the humid sections of the Pacific Northwest, the greatest damage usually occurring on the summer and fall varieties. It closely resembles black rot, but may be distinguished from it by its velvety appearance.

Brown rot is greatly delayed by low temperatures, yet is less retarded by cold storage than any of the rots previously mentioned.

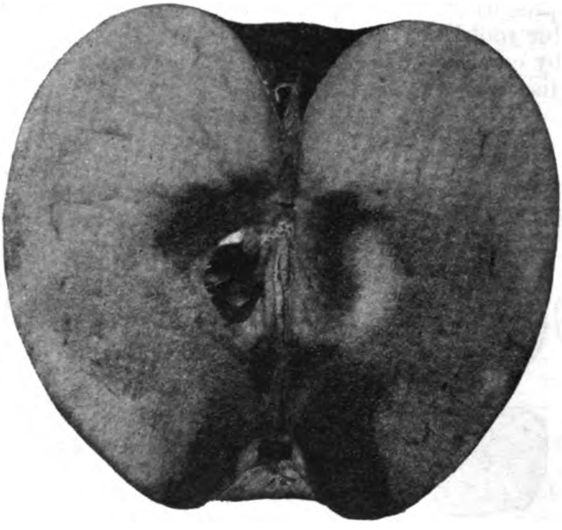

FIGURE 22.—Internal breakdown of a Stayman Winesap apple

GRAY MOLD

Gray mold[12] is a parasitic storage disease that often causes serious losses. Its appearance is much like that of blue mold, but it is somewhat firmer and has a distinctly sour taste that is in marked contrast to the musty odor and taste of the former. Its spread from one apple to the other is by contact rather than by a scattering of spores. It is greatly delayed by cold but will finally destroy infected apples even at cold-storage temperatures.

INTERNAL BREAKDOWN

Internal breakdown is a nonparasitic disease associated with large and overripe apples. It occurs on apples from the various fruit sections of the United States and has been reported from Australia under the name of "sleepiness." It occurs on practically all varieties, but is most serious on the summer and early fall apples. It is characterized by a breaking down and browning of the interior of the apple. (Fig. 22.) The riper side of the apple is often more seriously affected than the greener side and the blossom half worse affected than the stem half. During the earlier stages the flesh may be found quite moist, but it later becomes spongy and rather dry and "mealy." The skin usually retains its normal appearance, but is sometimes slightly duller and darker and in the later stages of the disease frequently cracks outward. The presence of the disease can usually be detected by the spongy softness of the apple.

---

[11] *Sclerotinia cinerea* (Bon.) Schrot.
[12] *Botrytis* sp.

Internal breakdown is particularly common on overmature apples and on those that have been forced late in the season. It may appear at picking time but is largely a storage disease. It is a condition that characterizes the end of the life of the apple, but when it appears prematurely it may be regarded as a definite disease. Delay in the packing house or in transit may be responsible for its appearance later in storage or upon removal. In commercial-storage experiments with Stayman Winesap apples it was found that internal breakdown was greatly decreased by the use of ventilated barrels and by storing in ventilated rooms. The disease is particularly serious in common storage, but fruit with a decided tendency to the disease can not be relied upon for late keeping even in cold storage.

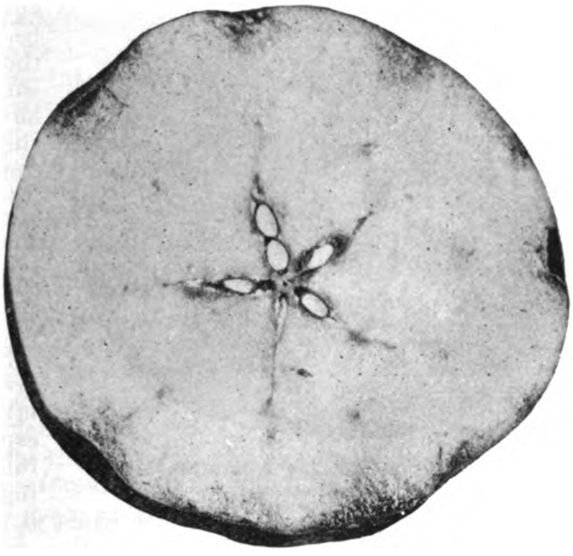

FIGURE 23.—Injury on a Stayman Winesap apple resulting from bruises while frozen

FROST INJURY

The freezing of apples in transit or in storage results in such a variety of effects that it is difficult to give a definite characterization. Frost injury bears a close resemblance to internal breakdown, but the internal browning that results from freezing extends to the surface of the apple, the affected tissue is more watery, and the conducting vessels usually show up prominently as dark-brown strands extending through the flesh. Unlike internal breakdown, frost injury may appear on any part of the apple and on the small green fruit as well as on that which is overripe.

Apples will stand a temperature several degrees below 32° F. without freezing, but reach their limit for cold resistance at about 28° F. Some varieties are touched with frost at this temperature, while others remain free from it. Slightly frozen apples can usually be thawed out in a moist atmosphere without showing injury. Their quality, however, is not as good as before the freezing. Apples are greatly damaged by any bruises made while they are frozen, and if frosted apples are to be saved, great care must be taken in handling the packages. (Fig. 23.) Apples that have been badly frozen or that have had repeated light freezes usually show frost injury, regardless of the methods of thawing.

that have had repeated light freezes usually show frost injury, regardless of the methods of thawing.

SOFT SCALD

Soft scald is a nonparasitic disease that is particularly common on the Jonathan and Rome Beauty varieties. In Australia it is known as Jonathan scald. It produces sunken blisterlike effects that extend over the apple in peculiar patterns. (Fig. 24.) Before exposure to the warm air the diseased spots on red fruit surfaces may have a whitish or pink color and the flesh beneath also be pink, the effects apparently being produced by a spread of coloring matter from the skin into the flesh. After exposure to warm air the scalded area and the flesh beneath become light brown in color. The affected tissue is very soft and the line of demarcation between it and the healthy tissue is extremely sharp. The disease resembles certain types of frost injury rather closely, and damages have frequently been paid for frost when the trouble was really soft scald. Frost injury, however, seldom shows the clear-cut margin and the soft, light-brown flesh that characterize soft scald. Secondary fungous infections sometimes follow soft scald, spotting the brown area with black.

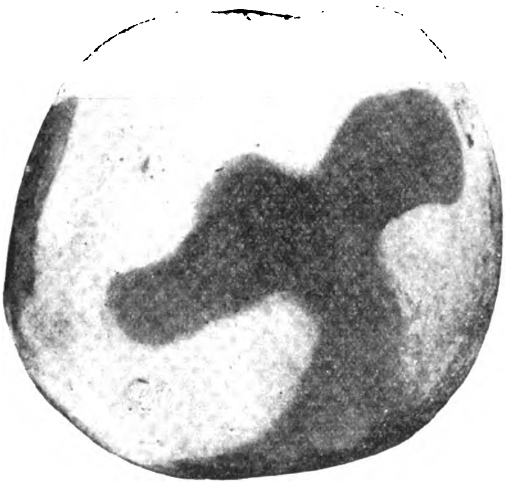
FIGURE 24.—Soft scald on a Jonathan apple

Soft scald is apparently due primarily to a deficiency in oxygen in the air surrounding the apples. It can be produced by inclosing apples for a few days in an air-tight jar at living-room temperature. In commercial practice the dangers from the disease may be greatly increased by delays in reaching storage, especially if the packages are tight and held without opportunity for ventilation. Under cold-storage conditions soft scald is much more likely to develop at temperatures that border on the freezing point for the apples than at temperatures a few degrees higher.

SCALD

Scald is a transportation and storage disease that is produced by the gases given off by the apples themselves. It is particularly serious on the York Imperial, Grimes Golden, Arkansas (*Mammoth Black Twig*), Rome Beauty, Rhode Island Greening, Stayman Winesap, Wagener, and Baldwin varieties, and it occurs at times on almost every variety of apple.

sap, Wagener, and Baldwin varieties, and it occurs at times on almost every variety of apple.

Scald can be distinguished from all other apple diseases by its preference for the greener side of the apple. In mild cases of the disease the apple is merely tinted with brown (see title-page illustration), but in more severe cases the entire skin layer is killed and sometimes broken down to the extent that it will slough off readily from the flesh. In some instances the flesh becomes dead and brown to a depth of half an inch, and the disease takes on the appearance of an apple rot; but true rot usually spreads down into the flesh in more or less conical shape, while scald is usually diffuse, spreading over a large area without having much depth. An apple that has had its skin killed by scald becomes the ready prey of the various rot organisms, and they soon finish the work of destruction that the scald has begun.

It has been generally believed that scald is due to the warming of the fruit after it has been removed from cold storage. This idea comes from an erroneous interpretation of very familiar facts, and this misconception in regard to the nature of scald has often resulted in throwing the responsibility for its occurrence upon the wrong party. It is true that apples usually show but little scald while held continuously in cold storage, and it is also true that fruit apparently free from disease may become badly scalded after exposure to warm air for a few days; but the apples were already potentially scalded while still in storage and merely required the open air and the higher temperatures to allow their death processes to be completed. Experimental evidence indicates that the real cause of scald is to be found in the accumulation of certain gases given off by the apples themselves.

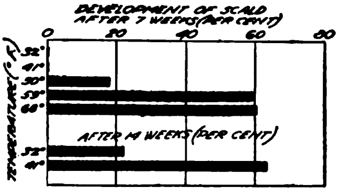

FIGURE 25.—Effect of temperature on the development of scald on Grimes Golden apples. The upper part of the figure shows the percentage of scald at the various temperatures at the end of 7 weeks; the lower part, the percentage of scald at the lower temperatures at the end of 14 weeks. At this time no apples were left at the higher temperatures

The responsibility for scald does not always lie in the same quarter. Its occurrence is influenced by orchard, packing-house, and transportation as well as by storage conditions. Large apples and those that have been forced late in the season by heavy irrigation or rains have an increased susceptibility to scald. Apples that have been scarred and russeted by powdery mildew are rendered more susceptible, while those from trees that have been badly affected with cedar rust are very resistant to scald. Fruit that is picked green is much more susceptible than that which is left on the trees till well matured. The holding of apples in closed packing sheds or in unrefrigerated cars may be responsible for the development of scald later in storage or upon removal from storage. Placing large quantities of warm fruit in a particular storage room instead of distributing it in several rooms is likely to result in delayed cooling and in heavy losses from scald.

The development of scald is much more rapid at high than at low temperatures. (Fig. 25.) Apples scald far less in boxes, crates, or ventilated barrels (barrels with 15 holes three-fourths of an inch by 4 inches cut in the staves) than in the usual commercial barrels, especially if the storage room is allowed considerable change of air.

They scald far less when located near the door of the storage room than when in the back corners away from the aisles. Open stacks and air spaces contribute to the prevention of scald.

The most efficient and practicable method of scald control is that of packing the apples in oiled (not waxed) paper. (Fig. 26.) Oiled wraps should be used on the boxed apples and shredded oiled paper on the apples in barrels, hampers, and baskets. About a half pound of shredded paper is required for each bushel of apples, and it must be well distributed in the package, practically every apple having more or less contact with the paper. The oiled wraps and the shredded oiled paper should carry at least 15 per cent of their finished weight in odorless, tasteless mineral oil (1 pound or more to each 1,600 to 2,000 wrappers), and 18 to 20 per cent of oil or more is desirable, especially with the more susceptible varieties.

INTERNAL BROWNING

Internal browning is a nonparasitic storage disease that is decidedly regional in its occurrence. It has never been reported as of economic importance in the United States except on the apples from the Pajaro Valley in California. The Yellow Newtown is the important storage variety of this section. Internal browning differs from internal breakdown in the fact that the affected tissue is not soft, and also in that the browning first appears as somewhat elongated areas radiating outward from the central portion of the apple and from the primary vascular bundles.

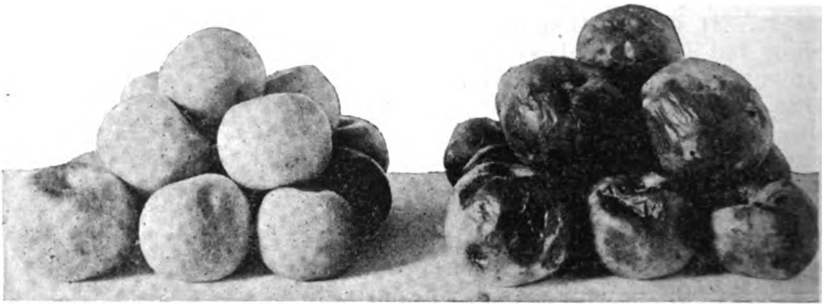

FIGURE 26.—Effect of oiled wrappers in scald prevention. These York Imperial apples were removed from cold storage on March 5 and photographed on March 15. Those on the left were wrapped in oiled wrappers; those on the right were unwrapped. At the time of removal from storage the two lots looked alike, but three days later the unwrapped apples were badly scalded, and at the end of 10 days they were almost entirely rotten, as shown in the illustration. The apples that had been held in oiled wrappers while in storage were still sound after three weeks in a warm laboratory

Internal browning is most effectively controlled by storing the apples at a temperature of 36° to 40° F. The usual cold-storage temperatures are particularly favorable to the development of the disease.

THE STORAGE LIFE OF APPLES

It is generally recognized that each variety of apple has its own storage limitations and that the keeping quality of the fruit varies from year to year. Dealers plan to dispose of their apples while they are still in good condition, and if it is found necessary to hold them till they are near the end of their storage life a close watch is usually kept to see that their limit is not exceeded. In spite of these precautions large quantities of apples fall prey to rots and scald instead of serving their purpose as food. This loss is not all sustained by the dealer, but may be passed along to the retailer and finally to the consumer. The relation of supply and demand and the behavior of the markets are sometimes responsible for fruit being held too late, but much of the loss on stored fruit is due to misjudgment in regard to its storage life, abuses that destroy its protective skin layer, and faulty shipping and storage conditions.

Fruit spot, stigmonose, and even small blotch specks usually have little effect upon the storage life of the fruit; but scab, black rot, and bitter rot specks may greatly shorten its life. Apples from trees affected by anthracnose or perennial canker and those showing a tendency to bitter pit will probably become diseased even in cold storage. Coarse overgrown apples and apples that are forced late in the season can never be relied upon for late keeping. The sound skin of the apple forms an almost complete protection from storage rots, but punctures and scratches pave the way for early decay. When fruit is placed in cold storage immediately upon picking, the rots develop slowly; but if the rot organisms can have a week's start on the warm fruit they will make a rather rapid growth even at 32° F. Scald is the most deceptive of all the storage troubles. Apples may become badly scalded while in storage, yet appear entirely healthy until exposed to warmer air. This peculiarity of the disease has often resulted in heavy losses and serious misunderstandings in connection with afterstorage shipments of fruit, and it has served as a great handicap in the distribution of apples to smaller centers. The time of the appearance and the severity of scald may be somewhat influenced by the growth conditions in the orchard, but they are largely determined by the treatment that the fruit receives after it has been packed.

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U. S. GOVERNMENT PRINTING OFFICE: 1935

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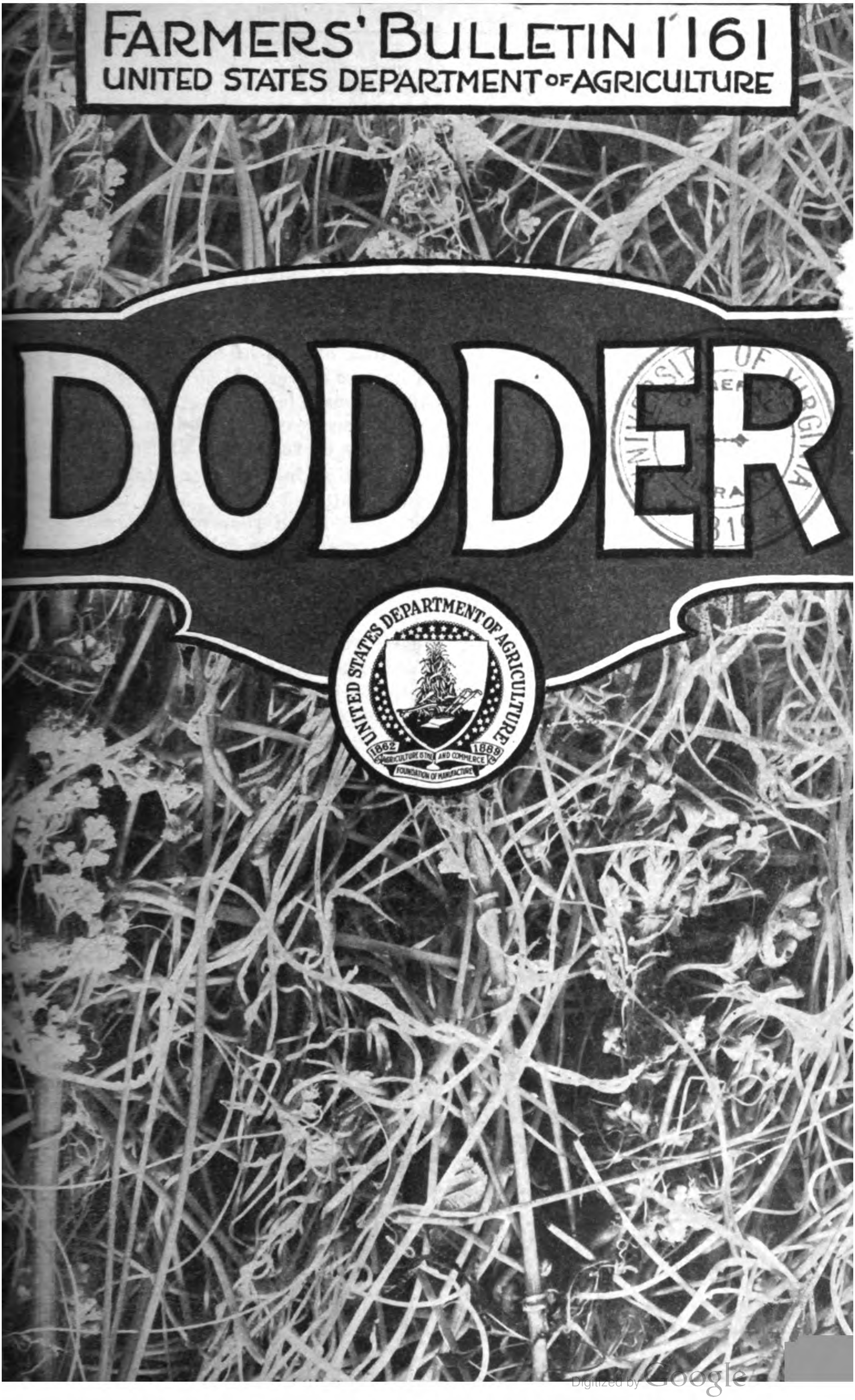
FARMERS' BULLETIN 1161
UNITED STATES DEPARTMENT OF AGRICULTURE

DODDER



UNIVERSITY OF VIRGINIA

DODDER is a parasitic plant, infesting clover and alfalfa chiefly. It is a bad weed in Europe, though conditions in the United States are not as favorable as in Europe for damage by dodder; hence the appearance of the pest on the farm should not occasion undue alarm. Nevertheless, dodder may cause a great deal of damage, and it should not be allowed to grow unmolested.

Dodder is usually introduced on the farm by impure seed. Other means are infested hay; moving objects, such as animals and wagons; irrigation water carrying seeds and pieces of stem; and viable dodder seeds contained in stable manure.

Dodder seed, with the exception of that of large-seeded dodder, may be cleaned from impure clover and alfalfa seed by screening. It is practically impossible to remove large-seeded dodder by screening. The seeds of field dodder are also difficult to remove entirely from clover and alfalfa seed.

During the first season of infestation in clover or alfalfa, dodder usually occurs in small scattered areas. Such infested areas should be either mowed and removed before the dodder matures seed or else burned in the field. If seed has formed, burning is the only remedy, since it kills not only the plants but also any seeds of dodder which may be lying on the soil surface.

If the infestation is so great that patch treatment is impracticable, the crop may be either plowed under or utilized for hay and the aftermath closely grazed to prevent seed from forming. Sheep are especially useful in grazing dodder. If dodder seed has formed and the crop has been very seriously damaged, the safest method is to cut the crop, allow it to dry, and burn it in the field.

Dodder does not attack cereals; consequently oats, wheat, etc., should be incorporated in the rotation following the infestation of the soil with dodder seeds. A tilled crop, such as corn, will cleanse the soil of most of the dodder seeds. In place of clover or alfalfa, other legumes, such as soy beans, velvet beans, and cowpeas, may be grown, since dodder never damages any of these crops. The seeds of dodder in the soil may remain viable for a period of five years or longer.

A number of cultivated crops besides clover and alfalfa are subject to dodder infestation; the most important of these are sugar beets, onions, and flax.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. January, 1921

A1.9:1161

DODDER.

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THE NOXIOUS CHARACTER OF DODDER.

DURING RECENT YEARS an increasing number of complaints of dodder, or love vine, have been received from all parts of the United States. The weed seems particularly troublesome in southern California, Virginia, Utah, Kentucky, and Colorado and in all regions in which clover and alfalfa are raised for seed. Although a noxious weed, dodder is not to be feared in the United States in the same degree that it is dreaded in Europe. In parts of Europe, especially in certain regions of Germany, the production of clover seed has ceased because of the ravages of dodder. The conditions in this country do not seem to be as favorable as in Europe for the development of dodder; hence the discovery of dodder on the farm should not be the occasion for serious alarm but rather for the employment of a well-conceived and systematic plan for its extermination. Eradication is not difficult if intelligent thought and action are devoted to the problem. Dodder has been more legislated against than any other weed, with the possible exception of Canada thistle.

COMMON NAMES OF DODDER.

As with all our troublesome weeds, the common names by which dodder is known vary according to locality. These various names in different parts of the country are frequently descriptive of the characteristics of the plant. These common names, in addition to dodder and love vine, which are most frequently used, are strangleweed, devil's-guts, goldthread, pull-down, devil's ringlet, hellbind, hairweed, devil's-hair, and hailweed. The plant upon which dodder grows is called the host. For example, flax is the host for flax dodder and clover the host for clover dodder.

DESCRIPTION OF DODDER.

When large enough to become noticeable, dodder is a slender twining parasite. (Fig. 1.) The tough, curling, threadlike, leafless stems (fig. 2) are usually yellowish or of orange color, but they are sometimes tinged with red or purple and occasionally are almost white. Close examination of the stem will reveal minute scales, the rudiments of leaves.

The tiny flowers occur in massed clusters (fig. 3) from early June until frost. They may be white, pink, or yellowish, and the ordinary flower parts are barely visible to the naked eye. The tiny gray to reddish brown seeds are produced in abundance, a single plant being capable of maturing upward of three thousand. Seeds ripen from July until frost. In occasional adverse seasons no flowers are formed.

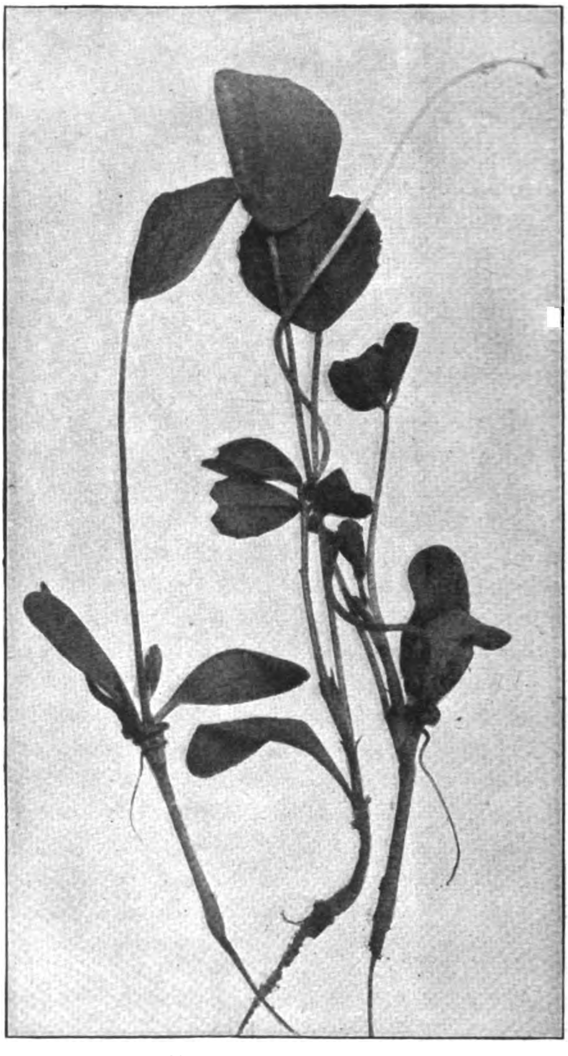
FIG. 1.—Young alfalfa seedlings attacked by alfalfa dodder. Note especially how the lower portions of the dodder stems have withered and died, thus losing connection with the ground.

Usually during the first season of infestation, dodder is noticeable in the field in the form of scattered yellowish areas. If allowed to produce seed and clover or alfalfa is grown the second season, so much dodder will frequently be present that the entire field will turn yellowish, the color of the dodder predominating over that of the leguminous crop.

SPECIES OF DODDER AND PLANTS WHICH THEY ATTACK.

Altogether about 50 species of dodder are found in America, about 32 of which are native. Usually the native dodders are not as troublesome as the introduced species. The field dodder,[1] one of our troublesome native species, now occurs in Europe. The several species of dodder are very similar in appearance, and an expert is required to distinguish one from another. For this reason, no attempt will be made to describe the different species.

It is important to know, however, that some of the dodders show marked preference for certain crops; as, for example, the small-seeded alfalfa dodder, which is practically never very harmful on any crop except alfalfa, though it may grow on other plants. Again, flax dodder in its growth is practically restricted to the flax crop.

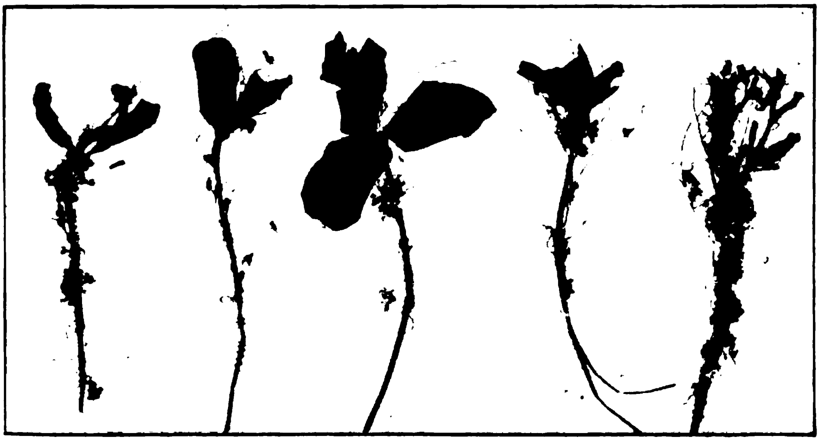

FIG. 2.—Branches of clover infested with dodder.

Conspicuous exceptions to this rule are the common dodder and the field dodder, which seem indifferent as to their hosts, attacking plants as diverse as ragweed and onion. None of the dodders affect oats, wheat, or other cereal crops.

A knowledge of the species infesting a crop is frequently of practical importance. For example, clover dodder[2] rarely seeds in the United States; hence it is to be feared only during the first season after sowing and not thereafter, although under favorable conditions it may live over by means of stems. Again, the large-seeded alfalfa dodder is damaging usually to alfalfa only and ordinarily will not seriously harm clover. Furthermore, it is important to be able to recognize the various species of dodder by means of the seed found as impurities in commercial seed. Thus, the small-seeded alfalfa dodder causes damage throughout the West, but is not to be feared in the East. It is suggested that, in order to determine species, either the seeds found in commercial seed or specimens of flowers collected in the field be sent to the State agricultural experiment station or to the United States Department of Agriculture for identification.

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[1] *Cuscuta arvensis.*

[2] *Cuscuta epithymum.*

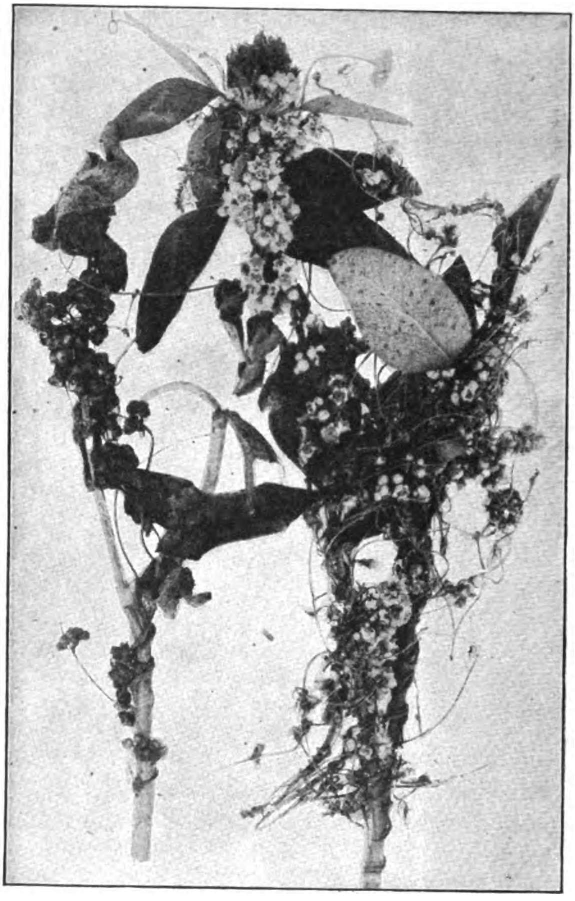

FIG. 3.—The specimen at the right shows dodder in flower, while the one at the left shows dodder in fruit. The host plant is red clover.

The species of dodder which are most damaging in the United States and their host plants are described in the following paragraphs:

Small-seeded alfalfa dodder.[3]—The small-seeded dodder was introduced from southern Europe and occurs in the West, but is not found in the East. It attacks a number of plants, but is particularly troublesome in alfalfa.

Field dodder.[4]—Unlike most species, field dodder shows little preference as to the plants which it attacks, since it will grow on leguminous crops and wild plants with equal facility. The stems of this species are pale yellow in color, a characteristic which is useful when determining the species in the field. Field dodder is a native species, growing in most parts of the United States, but causing the greatest damage east of the Mississippi River. During certain seasons when climatic conditions are favorable for its development, this species is unusually prevalent. Its seed is a common impurity in commercial seed, and this species is one of the most destructive of all the dodders.

Clover dodder.[5]—Clover dodder shows a decided preference for clover and alfalfa. It is an introduced species, occurring in parts of the West and found in the East from Maine to Pennsylvania. Its maximum damage occurs during the first year in fields planted with imported seed, since it rarely seeds in the United States. The stems of clover dodder are distinctly reddish in color.

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[3] *Cuscuta planiflora.*
[4] *Cuscuta arvensis.*
[5] *Cuscuta epithymum.*

Large-seeded alfalfa dodder.[6]—The large-seeded dodder attacks a number of plants, but exhibits a decided preference for leguminous crops, particularly alfalfa. It is a native species, common westward, rarely found in the East, and but occasionally in the South.

Common dodder.[7]—The common dodder resembles the field dodder in its indifference to the plants which it may attack. It is usually the species complained of as attacking garden ornamentals, and it may even infest hedges and willows. It is native in the United States.

Chilean dodder.[8]—Chilean dodder attacks clover and alfalfa. This is a common South American species which was introduced into the Mississippi Valley and California, where it caused some loss. It has been little feared during recent years, although the seeds of this species are frequently found in red-clover and alfalfa seed from South America.

Dodder is of economic importance principally because of the damage it causes in clover and alfalfa. For this reason the term "dodder," as used in the following pages, refers to clover and alfalfa dodders unless otherwise specified.

Dodder is a parasite. Soon after it establishes connection with a host plant (usually clover or alfalfa), dodder loses its hold on the ground and lives entirely on the host.

LIFE HISTORY OF A SINGLE DODDER PLANT.

As an example to illustrate the life history of a single dodder plant, we may select clover dodder.[9] All dodders reproduce from seed. (Figs. 4, *a*, and 5.) The tiny seed germinates (fig. 4, *b*), using all its stored-up food in the production of a slender yellowish shoot, somewhat resembling a bent toothpick. (Fig. 4, *c*.) This leafless, almost rootless, stem rotates until it comes in contact with a congenial host, such as clover. (Fig. 4, *d*.) With some species of dodder the seedling may attack almost any plant growing in the field, but will leave this temporary host as soon as it can climb within reaching distance of near-by clover or alfalfa. In case suitable contact is not established, the temporary stem lies dormant on the soil for four or five weeks and then dies.

If a suitable host is encountered, the tiny stem immediately begins to climb by encircling the host plant. (Figs. 1 and 4, *e*.) Let us say,

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[6] *Cuscuta indecora.*

[7] *Cuscuta gronovii.*

[8] *Cuscuta racemosa chilcana.*

[9] In figure 4 alfalfa is shown as the host.

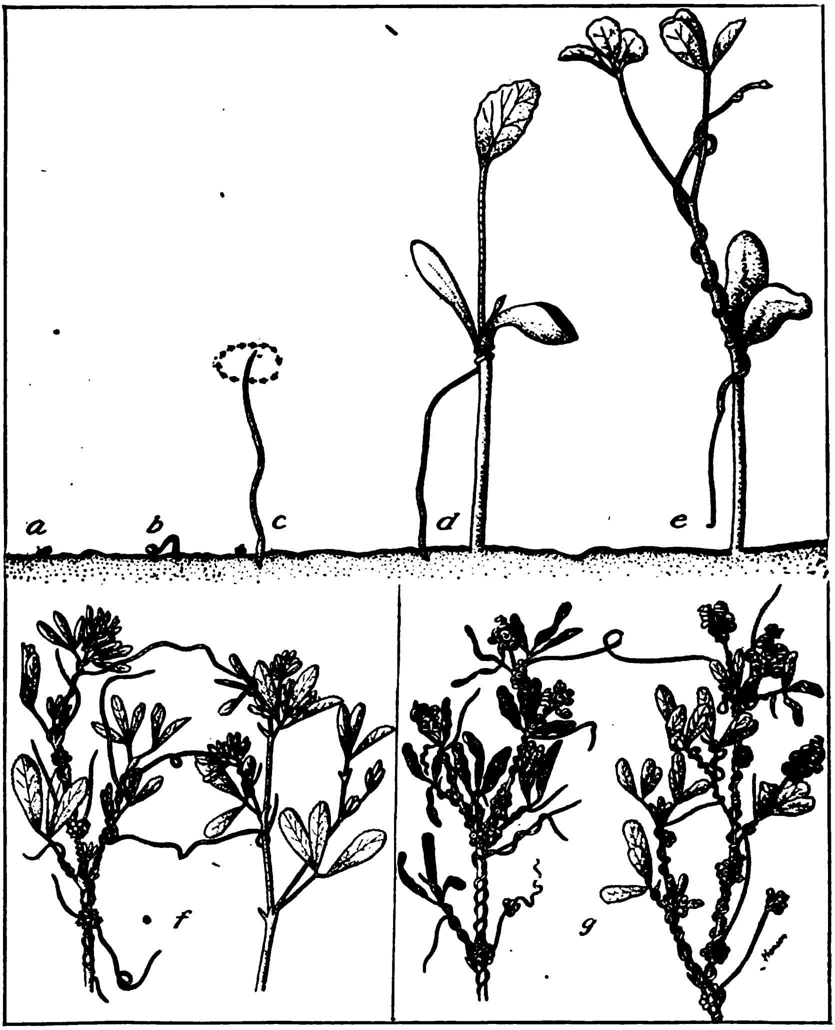

FIG. 4.—Diagrammatic representation of the complete life cycle of dodder on alfalfa plants. *a*, The seed. *b*, Germination of the seed. *c*, Young dodder seedling, showing manner of rotation. Unless the seedling comes in contact with a suitable host plant it will perish. The usual host is a legume, such as clover or alfalfa. Note the remains of the seed coats on the ground. *d*, The dodder seedling in contact with a suitable host plant (in this case, an alfalfa seedling) has wound itself around the stem of the host. *e*, Soon after contact, the dodder sends minute "suckers," termed haustoria, into the host tissues, which sap nutrition from the host plant. Note especially the characteristic withering of the lower portion of the dodder stem, which has now lost all connection with the ground. The dodder has climbed to the upper portions of the host, with which it will continue to grow until the alfalfa either matures or is killed previous to maturing. *f*, The originally infested alfalfa plant is shown at the left. Both the alfalfa and the dodder are in flower. The dodder tendrils have secured a hold upon an adjacent alfalfa plant previously not infested. *g*, The dodder and the alfalfa plants have now matured seed, although the presence of the dodded seriously interferes with the production of seed on the part of the host. The originally infested alfalfa plant (at the left) has withered and is almost dead, owing to the effects of the dodder. The death of the host also kills the dodder, but the parasite continues to live on the more recently infested host at the right, although this newer host likewise is showing signs of wilting. The dodder thus lives on by passing from one plant to another, while the seed carries the parasite over winter, to germinate the following spring and so start a new life cycle.

for example, that the host is clover. The dodder obtains its nutrition by sinking minute suckers, termed haustoria, into the food-conducting tissues of the clover (fig. 6), thus extracting elaborated food, which is utilized by the dodder in growth. These suckers actually secrete a substance called diastase, which dissolves the starchy substances in the host. The suckers may be considered as tiny roots which, instead of obtaining crude food from the soil, extract elaborated food from the clover. The base of the dodder soon shrivels and dries, thus losing all connection with the ground.

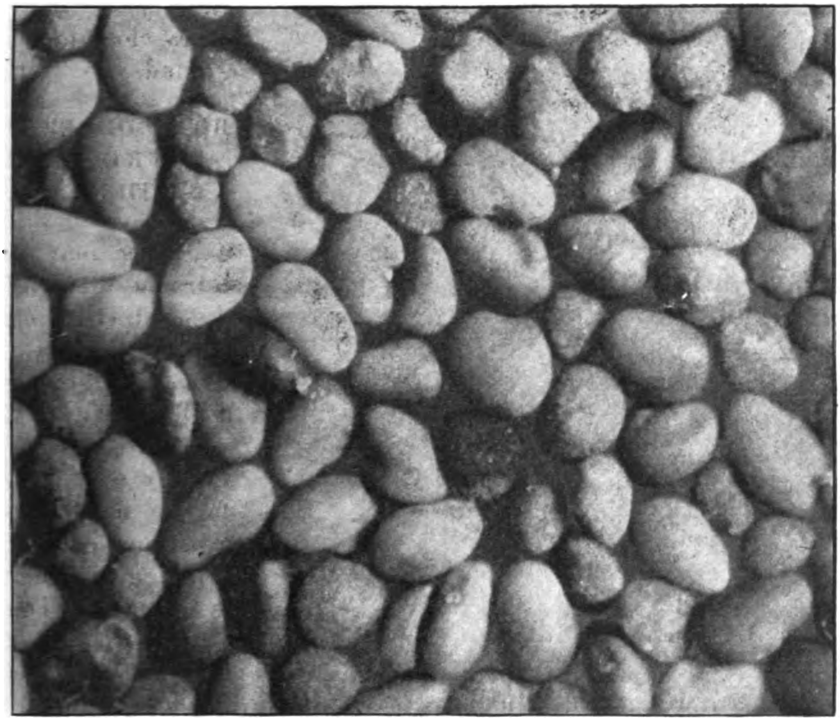

FIG. 5.—The seeds of dodder and red clover. Note the smooth seed coats and conspicuous scars of the red-clover seed and the roughened seed coats of the dodder seeds. Magnified nine diameters.

(Figs. 1 and 4, *e*. The dodder climbs, gaining growth and strength at the expense of the clover upon which it grows. As it reaches the top of the clover, the twisting tips of the dodder reach out and attack adjacent plants (fig. 4, *f*), until a gradually increasing circle of infestation is formed.

Meantime, the clover plants first attacked are usually killed to the roots (fig. 4, *g*) and the dodder upon them also dies, but the dodder on the newly attacked clover at the edge of the infested area keeps alive. During all this time the dodder is ripening seed, which falls to the ground, some of it soon germinating and attacking the young shoots arising from the roots of the hosts until the clover plants are entirely killed. Half-ripe dodder seeds germinate as readily as those fully matured.

The dodder winters over either by means of seed which lie dormant in the soil or by means of its stems, which are not always all killed by the winter's frost, but may renew growth when the favorable conditions of spring arrive. In Maryland little seed is produced, the dodder living over winter almost entirely by the stems close to the ground.

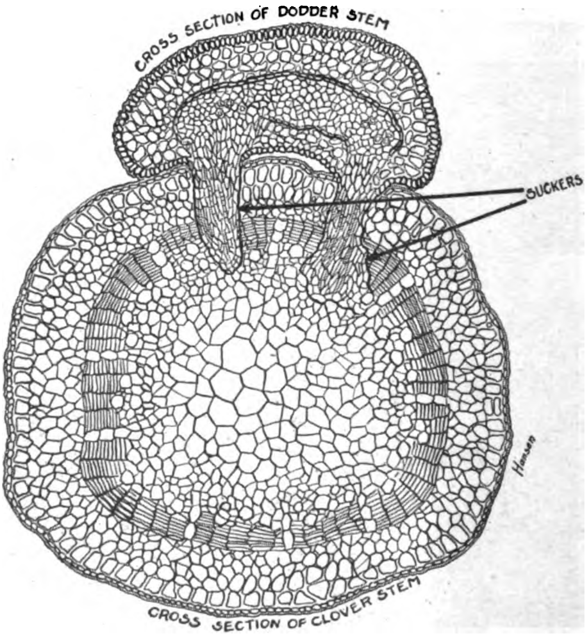

FIG. 6.—Cross section of clover and dodder stems. Note the two "suckers" (haustoria) by means of which the dodder extracts nutrition from the clover. Greatly enlarged. (Original.)

HOW DODDER IS INTRODUCED ON THE FARM.

Dodder may be introduced and disseminated on the farm by any of the following methods.

Impure seed.—Impure seed is by far the most common means of bringing dodder to the farm. This is true not only of domestic seed, but also of European seed. In many parts of Europe it is unlawful to sell clover or alfalfa seed containing even a single seed of dodder; consequently, a great deal of this seed is exported to the United States. This was particularly true before the passage of the Federal law which excludes all commercial seed containing one or more dodder seeds per 5 grams of commercial seed.

Dodder-infested hay.—Not only does hay secured from a dodder-infested field spread the pest by means of the seed, but the scattering of pieces of dodder stems may serve to spread the pest in case they come in contact with suitable hosts. It must be remembered that a piece of dodder branch when freshly cut can cause infestation almost as readily as a seed.

An important consideration in the spread of dodder is its ability to mature seed after it has been cut. An infested hay crop may be cut when the dodder is just past the flowering stage and the seeds have not as yet apparently matured, but the nutrition contained in the cut plants may frequently be sufficient to enable the dodder to ripen seeds. Furthermore, while dodder-infested hay is being transported, small clusters of flowers and fruit are frequently scattered and serve to spread the weed.

Never use clover or alfalfa seed obtained from a field known to contain dodder.

Moving men and objects.—Farm workers and moving objects, such as wagons and farm animals, occasionally carry dodder seeds, pieces of stems, and clusters of flowers from place to place. Manure containing the seeds of dodder sometimes adheres to the hoofs of animals and to other moving objects, and the weed is scattered by this means.

Irrigation water.—In the irrigated districts of the West, irrigation water frequently carries dodder by means of seeds and pieces of branches.

Infested manure.—Although dodder seeds may pass through the digestive tracts of grazing animals and retain their vitality, the danger from infested manure is somewhat remote unless very fresh manure is used.

HOW TO PREVENT THE INTRODUCTION OF DODDER ON THE FARM.

As with all weeds, and especially dodder, preventing their introduction on the farm is far easier than eradication after they have once gained a foothold.

When animals are allowed to graze where dodder grows, they should not have access to fields not infested, since they are likely to spread the weed by means of pieces of stems adhering to their coats and hoofs.

Dodder may be prevented from entering the farm by observing the following rules:

(1) Do not sow dodder-infested seed.

(2) Do not use dodder-infested hay.

(3) Do not allow animals from a dodder-infested field to have access to dodder-free fields.

(4) Do not allow dodder to grow where irrigation water may carry the pest from place to place.

(5) Do not use farm manure suspected of containing dodder seed until such manure has been composted for a period of at least six weeks.

Of these five rules, by far the most important is the one relative to the use of clean seed.

SUGGESTIONS FOR PROVIDING CLEAN SEED.

Before sowing clover or alfalfa the seeds should first be examined for dodder. This may be done either at home or by sending a sample to the State agricultural experiment station or to the Seed Laboratory of the United States Department of Agriculture. Unless one is familiar with the appearance of dodder seeds, they are difficult to detect, since dodder seeds range in size, according to species, from a grain of sand to that of alfalfa seed, and even larger. For adequate examination a magnifying glass is necessary. By studying figure 5, showing an enlarged view of dodder seed, more can be learned regarding the appearance of the seed of dodder than from pages of description. In general, these seeds are usually dull coated, with roughened or minutely pitted surfaces, and each seed has three flat surfaces, while the seeds of clovers are usually smooth, rounded, and possess a certain luster. Furthermore, the scar on dodder seeds usually is very inconspicuous, whereas the scar on leguminous seeds is clearly evident. Dodder seeds range in color from dark brown to green or yellow. Ability to recognize dodder seed will be found to be valuable when purchasing clover or alfalfa seed upon the market.

Learn to recognize the appearance of dodder seed. This knowledge is a safeguard against purchasing dodder-infested clover or alfalfa seed on the open market.

CLEANING.

The cleaning of impure seed in large lots is most economically done by seed companies equipped with special machinery for this purpose. On the farm the use of screens is helpful, although the complete removal of dodder seeds is very difficult. The removal of large-seeded dodder from clover and alfalfa seed has been found to be practically impossible. For other kinds of dodder the best results have been obtained by the use of a sieve made of wire having 20 meshes to the inch and of No. 30 to 34 thickness.

In general, home screening to remove dodder seed is at best a difficult and frequently an unsatisfactory procedure. Where the large-seeded dodder is abundant, it is best to discard infested seed entirely. It is possible to plant such seed so deeply that the dodder will have little chance to come out of the ground, but the danger to future crops makes this practice inadvisable.

If dodder is prevented from seeding during its first season's appearance, the danger of the weed appearing the following year is reduced to a minimum.

Where it is possible to procure from a neighboring farm seed known to be free from dodder, it is frequently better than the kinds of seed purchased on the open market.

KILLING.

A method of killing dodder seeds occurring as an impurity in the seed of clover and alfalfa has recently been devised in Europe and appears promising, but it has not as yet been sufficiently developed to be recommended. This method utilizes heat as a killing agent and consists in dry heating the infested leguminous seed at a temperature which will kill the seeds of dodder but will not harm the clover or alfalfa seeds.

METHODS OF CONTROL AND ERADICATION.

When dodder gains a hold on the farm, a well-planned intelligent system of attack should be formulated and then conscientiously followed. Such a plan should take note of whether the infestation is in spots or widespread and whether or not dodder seed has formed. It is of special importance to prevent dodder from maturing seed.

When dodder appears in small scattered patches, mow these areas before the seed has matured, (1) allowing the mowed plants to dry or sprinkling them with crude oil or kerosene, and burn them, dodder and all, or (2) feed the cut plants for hay.

ERADICATION IN SMALL AREAS.

From six to eight weeks after infested clover or alfalfa seed has been sown, the resulting crop will usually show small scattered patches of dodder occurring throughout the field. Such patches, especially in a large field, frequently can best be located from horseback. Work should be started immediately to destroy the patches before the dodder gets a good start, and especially before seeds mature, which is frequently as early as July. The patches should be cut close to the ground and the cut plants either burned or removed and used for hay, being careful not to scatter pieces of dodder stems on other parts of the field or on near-by fields.

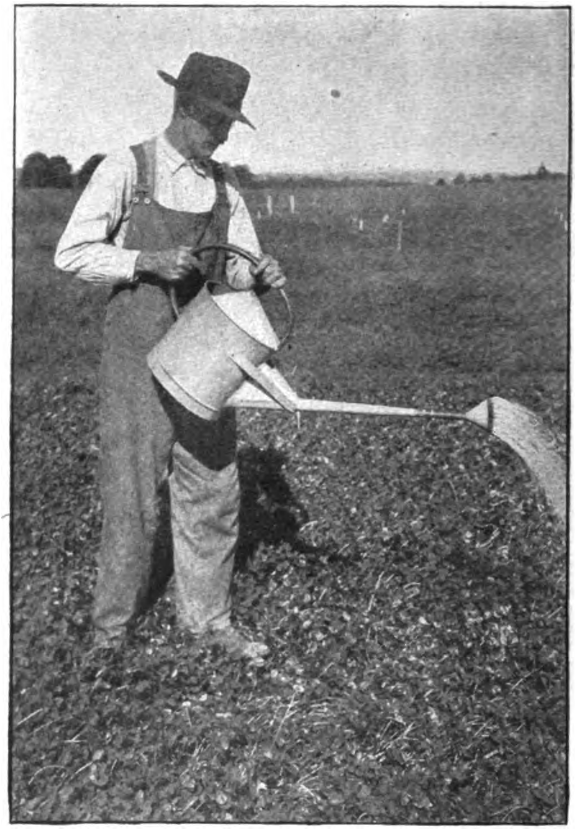

FIG. 7.—When dodder grows in small scattered areas in the field, each infested spot may be sprayed with oil previous to burning.

In case the dodder seed has ripened, it is best to destroy the patches entirely by burning. Four methods of burning may be used:

(1) Cut the patches with a scythe close to the ground, beginning well out on the margin of the infested area and working in. Allow the plants to dry; then burn.

(2) Sprinkle the infested areas with kerosene, crude oil, or orchard-heating oil, using a common sprinkling can for this purpose. (Fig. 7.) In a few days all the vegetation so treated will be dead. When well dried, ignite.

(3) Cover the infested areas with straw (fig. 8); then burn. (Fig. 9.)

(4) Burn the infested areas with a blow torch. This method is more expensive than any of the preceding.

Whichever method is used, it should always be followed by repeated hoeing of the surface of the infested spots for a period of at least three weeks. The hoeing will induce the germination of any surviving dodder seeds and will also destroy the resulting seedlings. Care should be used to cultivate extremely shallow, in order to prevent the deep burial of viable dodder seeds. Such deeply buried dodder seeds may constitute a constant danger to crops for years to come.

The practicability and efficiency of the burning method are well illustrated by the experience of a grower at Warrenton, Va., who in 1914 requested information from the United States Department of Agriculture as to the best method of treating small patches of clover and alfalfa dodder which had appeared in his fields. He was advised to destroy the patches by burning and followed the advice conscientiously. Since then, according to his own statement, no dodder has appeared in the treated fields.

It is important frequently to inspect the treated areas to see whether all the dodder has been killed. Oftentimes growths of dodder previously unnoticed may occur on near-by clover or alfalfa plants.

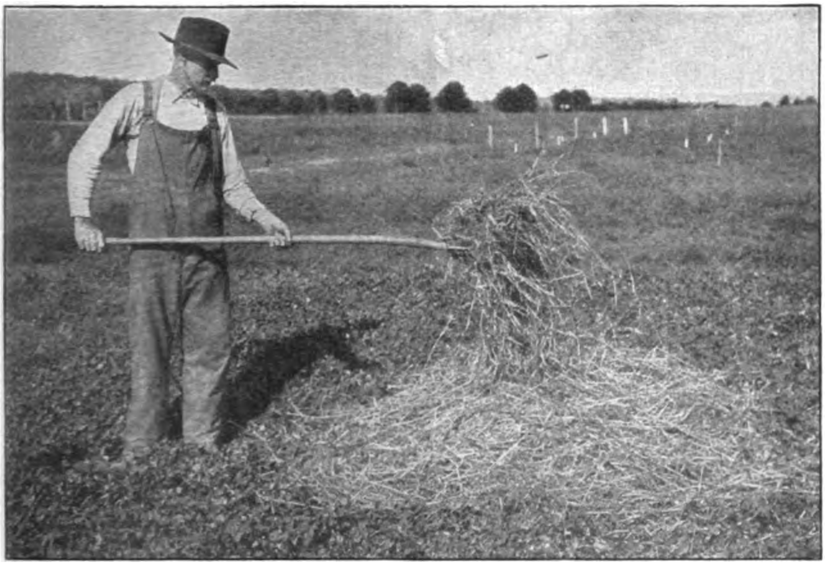

FIG. 8.—Small areas infested with dodder may be covered with straw instead of being sprayed with oil.

Burning not only kills the dodder plants but also kills the seeds on the soil. (Fig. 10.) Scattering oil-soaked brush or straw over the ground will usually insure sufficient heat to kill all the dodder seeds on the surface, because the oil will keep the heat close to the surface of the ground.

If clover or alfalfa is to be grown the following year, it is well to mark the treated areas and inspect them during the spring, to make sure that the pest has been completely eradicated.

ERADICATION IN LARGE AREAS.

When dodder occurs either as large patches or covering entire fields, it is usually an indication that the pest had been allowed to go to seed the previous year. If the dodder has matured seeds, the methods of attack differ from those to be used where dodder seeds have not ripened.

Methods of Eradication in Large Areas Where Dodder Has Not Matured Seed.

It is of extreme importance to attack the dodder before viable seed has formed. Any of the following methods may be used in case dodder seed has not matured.

Early mowing.—Mow the crop, dodder and all, before the dodder has had a chance to seed and then feed the hay to stock, preferably in the field. Animals are not harmed by eating dodder, though horses and cattle will usually reject it in favor of the clover or alfalfa. It is important not to delay the mowing too long, since dodder readily matures seed even on a cut crop. Mowing may best be done before any of the dodder flowers have opened. After the hay has been removed, the land may either be plowed and reseeded or else closely grazed in order to prevent the formation of a late crop of dodder seeds.

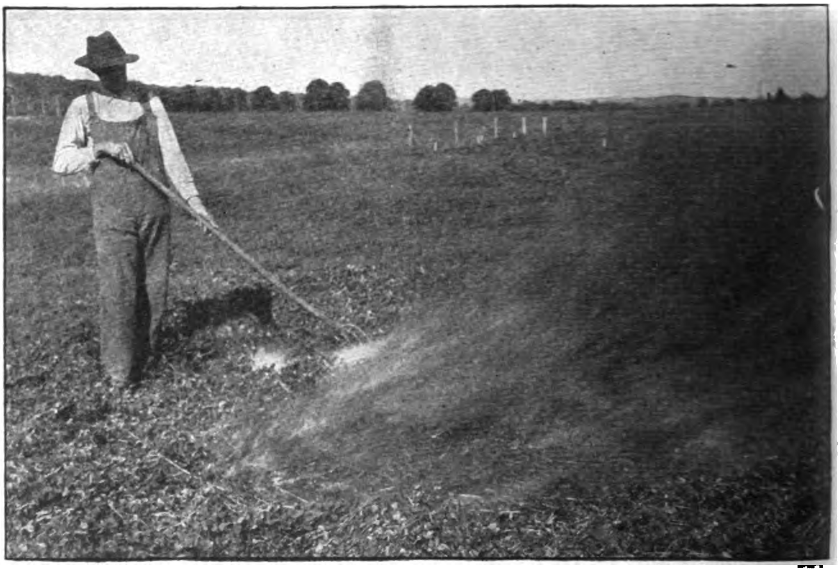

FIG. 9.—After either covering the infested area with straw or spraying with oil, it should be burned.

In the alfalfa fields of the West the common method of handling dodder-infested crops is to mow when the dodder flowers are about to open. After the first mowing the alfalfa stubble is harrowed. The second crop of alfalfa is likewise cut before the dodder has had a chance to mature seeds.

Grazing.—When the dodder plants are first noticed the field may be turned over to grazing animals. For this purpose sheep are particularly good, although hogs or any other grazing animals may be used. The field should be closely grazed during the remainder of the season. Inspection is necessary from time to time, so that no neglected areas of dodder will be allowed to go to seed. A fact to be remembered is that many weeds act as hosts to field dodder and common dodder; hence the fields, and especially the fence rows, should be kept clean of weeds, in order that the dodder be not carried over from year to year through their agency. This procedure is most important in the States east of the Mississippi River, since in this region the common and field dodders (both of which species commonly attack weeds) occur in greatest abundance.

Plowing.—Plowing the crop under, dodder and all, to be used as a green-manuring crop, is a good way to utilize a dodder-infested legume crop. It is important to make sure that none of the dodder has gone to seed, however, before deciding on the plowing method. In this connection it is well to remember that dodder seeds germinate readily in the early-milk or dough stage.

Methods of Eradication in Large Areas Where Dodder Has Matured Seed.

The menace of allowing dodder to go to seed is due to the fact that the seed remains viable in the soil for a period of five or more years, thus practically excluding the use of clover and alfalfa for that length of time. In place of clover and alfalfa, soy beans, cowpeas, or velvet beans may be used in some instances, since dodder never damages any of these crops.

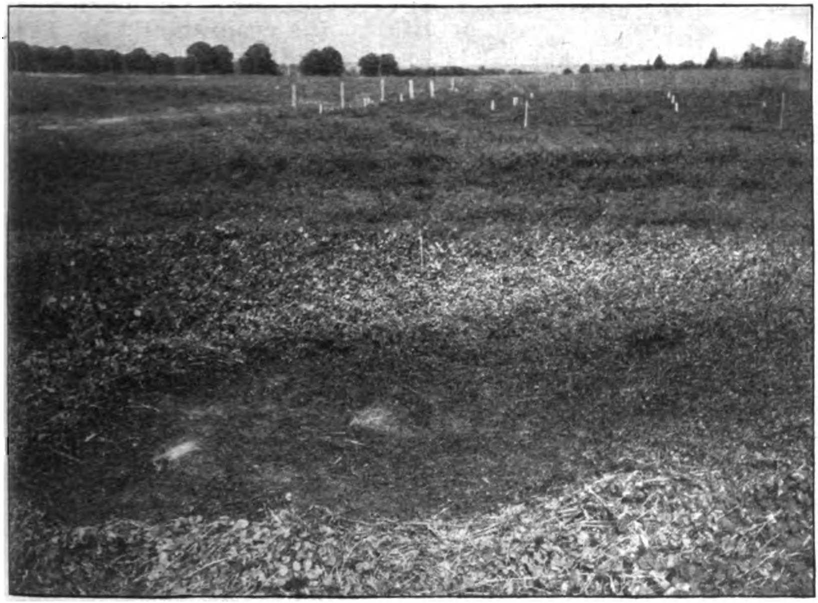

FIG. 10.—The infested area after being burned. Burning not only destroys the dodder plants but also any seeds which were lying on the surface of the soil.

When an entire field of clover or alfalfa is infested with dodder and the weed has been allowed to go to seed, the method best suited to conditions should be selected. The various methods which may be employed follow:

Burning.—In extreme cases, where the entire crop of clover or alfalfa has been practically destroyed by the dodder, cut the crop close to the ground and either allow the plants to dry or else sprinkle with kerosene or crude oil. The crop should then be burned on the ground. The purpose of the burning is not only to destroy all the vegetative parts of dodder, but likewise the seeds lying on the surface of the ground.

Following burning, the land should either be fallowed for the remainder of the season or plowed and planted to a winter cover crop, such as rye or oats. The following spring start a 5-year rotation, beginning with a tilled crop, such as corn or potatoes. During the next four years use a cropping system which does not include either clover or alfalfa. In planning this rotation a selection should be made which includes small grain crops, such as rye, oats, or wheat, tilled crops (like corn or potatoes), and such leguminous crops as soy beans, velvet beans, or cowpeas. Dodder will not attack the cereal crops, soy beans, velvet beans, or cowpeas, and the stirring of the soil due to cultivation of the tilled crop will tend to germinate any dodder seeds remaining in the soil. Dodder seedlings which may thus result can not survive cultivation; neither will they find suitable hosts to keep them alive. In selecting the tilled crop, the cultivated plants known to be susceptible to dodder should be used guardedly. A list of these susceptible crop plants is given under the heading "Dodder on hosts other than clover and alfalfa." Dodder-infested alfalfa fields in Utah are frequently broken up and planted to sugar beets as a means of cleaning out the dodder, even though it is known that sugar beets are susceptible to dodder attack. The continuous hoeing and cultivation which sugar beets receive during the growing season are considered the best methods of ridding the ground of the dodder pest. In case it is particularly desirable to grow clover or alfalfa during the 5-year period following the seeding of dodder, the clover or alfalfa should be closely grazed or cut early in order to prevent the maturing of seed of any dodder which may be present.

If dodder has been allowed to go to seed in large areas and has practically destroyed the entire crop of clover or alfalfa, the crop should be mowed and burned in order to kill not only the dodder plants but likewise the dodder seeds on the soil surface.

A dodder-infested crop of clover or alfalfa may be cut for hay and fed directly from the stacks in the field.

Utilizing the crop for hay.—In case the alfalfa or clover is worth saving, the crop may be cut for hay and fed directly from stacks on the infested field. In this connection, it should not be forgotten that the resulting manure will contain viable dodder seeds.

The following spring cut the dodder-infested clover or alfalfa for hay just before the dodder has opened its flowers. During the remainder of the season, closely graze the land, so that no dodder will be allowed to mature seed. Similar early-cutting and close-grazing treatment should be given any clover or alfalfa grown for the following four years, in order to prevent dodder seed from again fouling the land.

Cutting a dodder-infested crop for hay in which the dodder has matured seed is at best a risky procedure, since it not only permits the land to be fouled with the seed of dodder, but likewise involves the serious risk of scattering the weed to many other parts of the farm. The burning method is much safer, but it has the disadvantage of necessitating the destruction of an entire crop and is to be recommended in extreme cases only.

On land known to contain the seeds of dodder, use a 5-year cropping system consisting of plants which are immune to the attacks of the pest. The following plants are not susceptible to injury by dodder: Corn, soy beans, velvet beans, cowpeas, and small grains, such as oats, wheat, and rye.

CHEMICAL MEANS OF ERADICATION.

Various chemical sprays, such as solutions of iron sulphate (15 per cent), copper sulphate (5 per cent), sulphuric acid (1 part, concentrated, to 200 parts of water), salt, crude carbolic acid, sodium nitrate, and potassium sulphate, have been recommended for use against dodder. These chemicals are not only costly but are expensive to apply, and their application requires considerable labor of a disagreeable character. For these reasons, the use of chemical plant poisons as a means of controlling dodder is not ordinarily to be recommended. Furthermore, other methods are equally efficient and are usually more economical.

Dodder frequently matures seed after the crop upon which it is growing has been cut; therefore clover or alfalfa infested with dodder should be cut before the dodder flowers open. If this is done the dodder will not be likely to mature seed.

DODDER ON HOSTS OTHER THAN CLOVER AND ALFALFA.

INFESTATION OF CULTIVATED PLANTS.

Although the greatest damage due to dodder is in clover and alfalfa, various other crops are sometimes attacked. Among these crops, damage by dodder has been most frequently observed in the following cases:

Sugar beet.—In some sections of the country, particularly in Utah, beets have been damaged by dodder; severe infestations, however, are not common.

Dodder in sugar beets is usually confined to small areas and the damage is not heavy.

Flax.—Several years ago flax dodder[10] caused a great deal of damage in the flax-growing centers of the United States. So serious was the problem that the growth of flax was at one time discontinued in North Carolina, owing to the ravages of the weed. During recent years, however, very little damage has been recorded from this source, owing in part to the use of seed which was free from dodder impurity.

Cultivated plants infrequently attacked by dodder.—Among the cultivated plants subject to dodder infestation, but which, comparatively speaking, are infrequently attacked are grapevine, hemp, carrot, parsnip, turnip, bird's-foot trefoil, raspberry, cucumber, thyme, tobacco, eggplant, crape myrtle, willow, and the succulent parts of rose seedlings, the chrysanthemum, balsam, privet, and other garden ornamentals.

Treatment of dodder on crop plants.—In field and garden crops dodder seems to disappear in the process of regular crop rotation and thorough cultivation. When the infestation becomes sufficiently serious, the most practical solution seems to be to grow crops, such as corn and the small grains, which are not subject to attack by dodder. After four or five years of such treatment the dodder should be sufficiently cleaned out to allow the return to beets, etc.

Infestations of garden plants are rarely sufficiently bad to warrant special methods of eradication. In extreme cases the simplest remedy is to grow other garden plants in the place of those liable to attack.

DODDER ON WILD PLANTS.

A large number of wild shrubs and herbs serve as hosts to various species of dodder. These wild plants include willow, aster, goldenrod, four-o'clocks, ragweed, nettle, purslane, yellow trefoil, pigweed, sunflower, caltrop, wild carrot, shepherd's-purse, hazel, chondrilla, dandelion, viburnum, marsh elder, fleabane, horse nettle, honeysuckle, and several species of wild grasses.

It is of passing interest to note that dodders have actually been known to attack themselves, sinking suckers into their own tissue.

DANGER TO CULTIVATED PLANTS FROM WILD-PLANT HOSTS.

Usually the species of dodder growing upon wild shrubs, with the exception of common dodder and field dodder, will not attack any of our common farm crops. The danger of such attack, however, is always present on newly cleared land on which dodder grew. This fact was demonstrated by an interesting case of dodder infestation which was recently observed in Pennsylvania. A field of eggplants about half an acre in extent was planted on newly cleared woodland.

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[10] *Cuscuta epilinum.*

The eggplants became badly infested with dodder; so bad was the infestation that not a single fruit was formed on the parasitized plants, and the entire field was destroyed. The dodder was determined as hazel dodder,[11] a species not uncommon on hazel and other wild shrubs and on tick trefoil and other wild herbs, but never previously reported on cultivated plants.

The incident suggests that when woodlands infested with dodder are cleared, it is well to plant the land to crops known to be immune to attacks of dodder.

Most of the species of dodder commonly found along the edges of woodland adjacent to cultivated land are harmless and should not cause alarm. It is well to have such species identified, however, to be sure of their harmlessness. Specimens may be sent for identification to State agricultural experiment station or to the United States Department of Agriculture.

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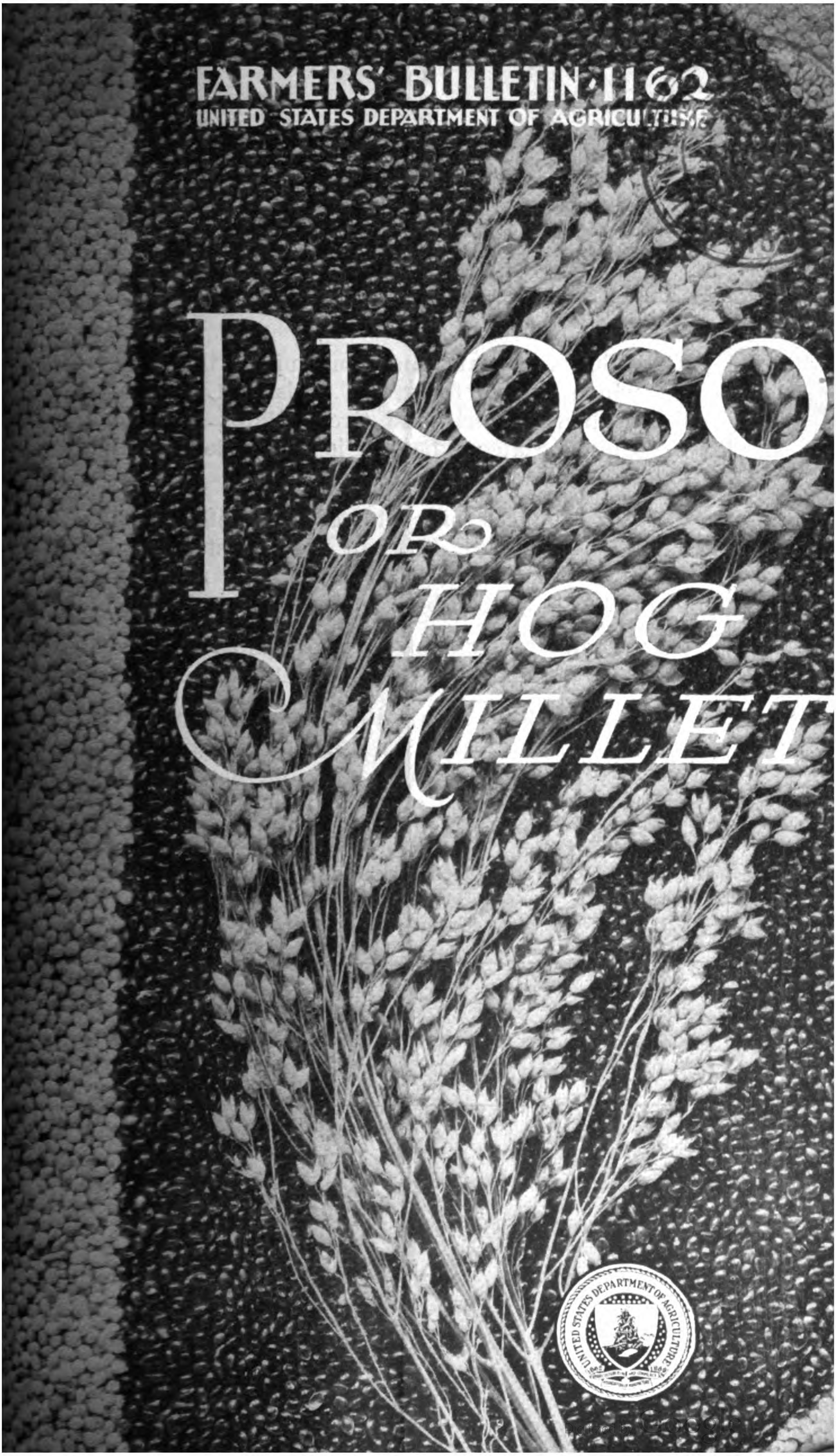
[11] *Cuscuta coryli* Engelm.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1926

FARMERS' BULLETIN 1162
UNITED STATES DEPARTMENT OF AGRICULTURE

PROSO OR HOG MILLET



PROSO is an early-maturing millet, the seed of which is used for grain. It is best adapted to the northern Prairie and Great Plains sections of the United States, where it is grown to a limited extent as a late-sown catch crop.

Proso produces fair yields of seed with a limited supply of moisture, but can not withstand severe drought. Other grains usually yield more than proso, but they must be sown earlier.

Turghai, Red Russian, Tambov, and Black Voronezh are the highest yielding varieties of proso.

Proso should be sown with a grain drill at the rate of 1 to 3 pecks per acre, from a few days to two weeks after corn-planting time, but it will usually mature seed if sown even as late as July 1. It is harvested and thrashed like other small grains.

In the United States proso is used chiefly for stock feed.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. October, 1920

A1.9:1162

PROSO, OR HOG MILLET.

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DESCRIPTION.

Proso, or proso millet, is the common millet of the Old World which has been grown since prehistoric times as an important grain crop for human food. It probably was first introduced into the United States by Russian immigrants and is grown only to a limited extent here.

In addition to the names proso and proso millet, this crop in this country is often called hog millet because of its frequent use as hog feed, broom-corn millet because of the shape of the head or panicle which somewhat resembles broom corn, and Early Fortune millet or Manitoba millet if it consists of either of these varieties.

Proso is distinguished from foxtail millet [1] and barnyard millet chiefly by the head or inflorescence (the seed-bearing part), which is a large open-branching panicle like oats. Proso has coarse, woody, hollow stems from 12 to 48 inches, but usually about 30 inches high. The stems are round or flattened and generally about as thick at the base as a lead pencil. The stems and leaves are covered with hairs. The stem and outer chaff are green, or sometimes yellowish or reddish green, when the seed is ripe. When thrashed, most of the seed remains inclosed in the inner chaff or hull. The seed of proso is larger and not so tightly held in the hull as are those of the millets of the foxtail group. The hulls of proso are of various shades and colors, including white, cream, yellow, red, brown, gray, and black. The bran, or seed coat, of all varieties is a creamy white.

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[1] For a more complete discussion of the millets of the foxtail group, see Farmers' Bulletin 793, "Foxtail Millet: Its Culture and Utilization in the United States," a copy of which may be obtained free on request to the Secretary of Agriculture, Washington, D. C.

THE PLACE OF PROSO IN OUR AGRICULTURE

According to the census of 1929, the latest available statistics, the leading States in the production of millet seed were Colorado, South Dakota, Tennessee, and Kansas. A part of this, especially in Tennessee and Kansas, consisted of millets of the foxtail group. No statistics are available to show the acreage of proso, but it is a minor crop. Seed companies in all parts of the United States offer proso seed for sale. It has been found to be best adapted to the northern prairie and Great Plains areas, including Minnesota, the Dakotas, northeastern Colorado, Montana, and Wyoming, and sometimes it is successful in Kansas and Nebraska. In the Texas Panhandle it is about as successful as other spring small grains.

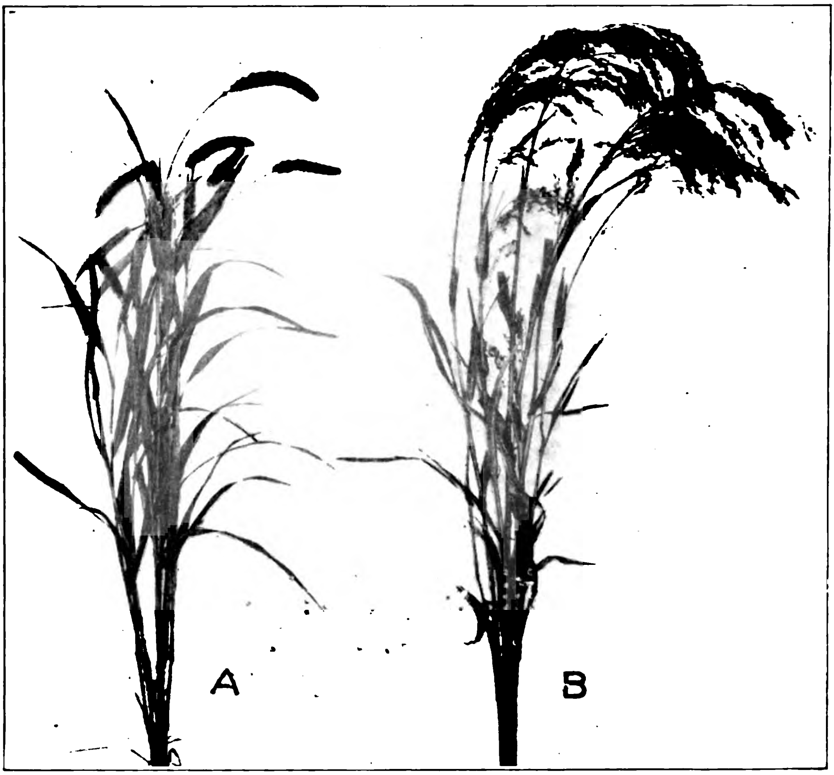

FIGURE 1.—A, Plants of Kursk foxtail millet; B, Black Voronezh proso

Except in northeastern Colorado, proso should be grown only as a catch crop and not as a part of a regular rotation. Under average conditions other cereals will outyield proso if they are sown at the proper time. In some localities other crops are more productive than proso even when sown late as catch crops. In the northeastern United States buckwheat is the best catch crop for grain; in the Southwest, grain sorghums are the most productive. In the humid sections of the United States millets of the foxtail group produce more seed than proso and are to be preferred as a hay crop. Flax is a more profitable catch crop than proso under certain conditions in Minnesota and the Dakotas, but proso ca grown on "flax-sick" soil. It will fight weeds somewhat better t flax, but not so well as foxtail millet; and it is not advisable to so on weedy land.

In nearly all localities where it is grown, the average yield of p in pounds of grain per acre is less than that of wheat, oats, or ba In rather dry seasons, however, proso often outyields other gra In the *Great Plains* area and the northern prairie region a var

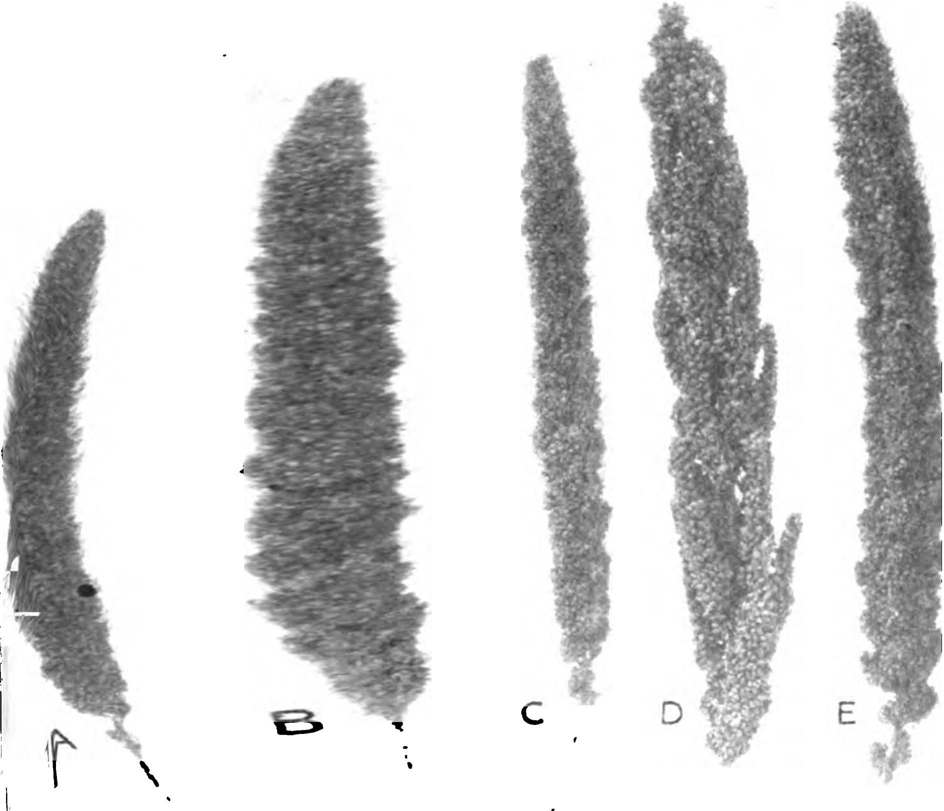

FIGURE 2.—Heads of five varieties of millet: A, Kursk; B, Hungarian; C, Com D, Japanese; E, Siberian. These millets are principally grown for hay. The Jap millet is closely related to the common barnyard grass; the others are foxtail var

of foxtail millet known as Kursk is grown to some extent. This uces more and better hay than any of the earlier maturing p varieties. A selected strain of Kursk millet has produced more than proso in the Panhandle of Texas, in eastern South Dakota, in southeastern Wyoming. In the central and western portion North Dakota and South Dakota the best varieties of proso h produced more seed than Kursk millet, although some of the tremely early and also some of the rather late varieties of proso l yielded less than Kursk millet. At some agricultural experiment stations where Kursk millet has outyielded proso, the best varieties of proso were not grown.

The best varieties of proso mature one to four weeks earlier than any variety of foxtail millet and can be sown that much later with a chance of obtaining a seed crop. They usually produce more seed than the foxtail millets on a limited supply of moisture. The seed of proso is larger, more easily ground for feeding, and probably makes a better feed than that of the foxtail millets. Proso should be sown in preference to foxtail millets only where a crop of grain is desired.

The place of proso in our agriculture thus is largely limited to its use as a late-sown catch crop for grain in the northern Great Plains area and a few other sections. When a crop of winter wheat has been destroyed by winterkilling or soil blowing, or when small grain or corn is destroyed by frost, hail, insects, floods, or early drought, or when seed of an early sown crop does not germinate, proso can be sown even as late as July 1 with good chances of obtaining a crop. Proso usually is sown on sod or stubble land which was plowed too late to sow to other crops. This permits a larger crop acreage than is possible where only early sown crops are grown.

Under extremely favorable conditions proso yields from 60 to 70 bushels per acre, but yields of 10 to 30 bushels per acre are the general rule. When sown at the most profitable rates of 1 to 3 pecks per acre, the rate of increase is not abnormally high, and the cost of seed for an acre of proso is as much as for other grains.

CLIMATIC REQUIREMENTS

Proso is sown in the spring and is adapted only to regions where spring grain is fairly successful. It is easily injured by frost either in the spring or fall and is not adapted to high altitudes or to localities where summer frosts occur. Moderately warm weather is necessary for the germination of the seed and growth of the plant. Even under favorable conditions proso grows very slowly during the first few weeks. Early and midseason varieties of proso require from 50 to 90 days from sowing to maturity, and unless there is a probability of at least 60 days until a killing frost occurs proso should not be sown. This crop does not ripen well, and frequently not at all, during cool autumn weather.

Proso has the lowest water requirement of any grain crop. At Akron, Colo., only about two-fifths as much water was required to produce a ton of proso seed as was necessary to produce a ton of grain of Kubanka durum wheat. Largely because of its shallow rooting habit, however, proso is less resistant to severe drought than well-adapted varieties of other grains and is sometimes a complete failure where wheat or barley produces a fair crop. Hot winds occasionally dry and kill the plant before it forms seed, even when there is available moisture in the soil. Proso is reported to produce crops in Siberia under an annual precipitation of 8 inches, but it can not be expected to do this in the United States, nor can it be regarded as even a safe crop during extremely dry seasons in the western portions of the Great Plains area. Attempts have been made to exploit proso fraudulently as a very high-yielding dry-land crop.

Proso is not so well adapted for growing under irrigation as most other crops, largely because it does not make sufficient use of an abundant supply of moisture.

SOILS ADAPTED TO PROSO

Proso is best adapted to a rich loam soil, but grows satisfactorily on nearly all types except coarse sandy soils. The proso plant is shallow rooted and a gross feeder, so that an abundant supply of available plant food near the surface of the soil is desirable. A crop of proso usually leaves the upper layers of soil somewhat impoverished, because of its shallow rooting and feeding habits.

VARIETIES

The varieties of proso are divided into three main groups, according to the shape of the head or panicle. Heads of each of these three groups are shown in Figures 3 and 4. These are further subdivided according to color of seed, color of chaff, height, and time of maturity.

Following is a key to the leading varieties of proso grown in the United States or proving of value in experiments conducted by the United States Department of Agriculture. The characters are also shown in Table 1.

KEY TO VARIETIES OF PROSO

Panicle spreading (*Panicum miliaceum effusum* Kcke.)
Seed white to yellow.
Chaff yellowish green.
Early to midseason.
Plant short to midtall.
Seed creamy white------------------------- *White Ural.*
Seed brownish yellow---------------------- *Hansen White Siberian.*
Seed red to brown.
Chaff partly reddish green.[1]
Early to midseason.
Plant short to midtall.
Seed reddish brown------------------------ *Tambov.*
Red Russian.
Plant midtall to tall.
Seed yellowish brown---------------------- *Turghai.*
Panicle loose, one-sided (*Panicum miliaceum contractum* Kcke.).
Seed white to yellow.
Chaff yellowish green.
Midseason to late.
Plant midtall to tall.
Seed creamy white------------------------- *White French.*
Seed brownish yellow---------------------- *Yellow Manitoba.*
Seed red to brown.
Chaff yellowish green.
Early to midseason.
Plant short to midtall.
Seed reddish brown------------------------ *Red Orenburg.*
Seed brown to black.
Chaff yellowish green.
Midseason to late.
Plant midtall to tall.
Seed brownish black----------------------- *Black Voronezh.*

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[1] Shortly before maturity the outer chaff becomes tinged with dark red or purple.

Panicle compact, erect (*Panicum miliaceum compactum* Kcke.).
Seed red to brown.
Chaff yellowish green.
Early to midseason.
Plant short to midtall.
Seed reddish brown______________________ ***Red Voronezh.***
Yellow Sarepta.
Early Fortune.
Red Lump.

All of the varieties of proso listed in the key, except possibly the White French, were originally introduced from Russia or Siberia.

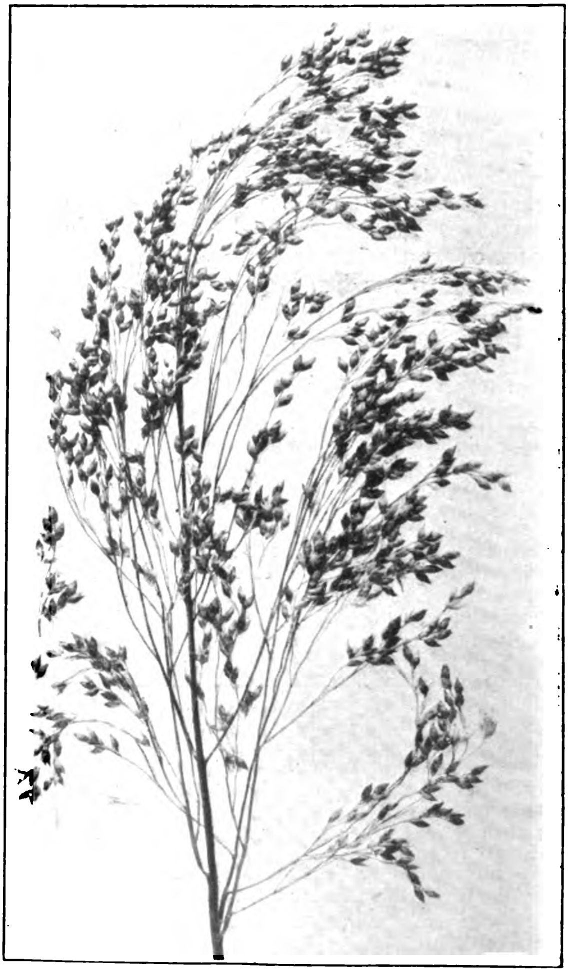

FIGURE 3.—A head of Turghai proso, showing the spreading type of panicle

Numerous varieties of proso introduced from China, India, and Italy have produced poor yields, chiefly because of their late maturity and susceptibility to drought. Altogether, more than 300 different lots of proso, representing many different varieties, have been obtained by the United States Department of Agriculture and grown in experiments, but only a few of these have produced good yields.

The leading varieties of proso now grown in the United States are the Yellow Manitoba and Early Fortune. The Hansen White Siberian, Red Russia, Turghai, Tambov, White French, Red Lump, and Black Voronezh are grown to a less extent, and considerable proso is grown without a name except the term "hog millet." The other varieties shown in the key have been grown only experimentally.

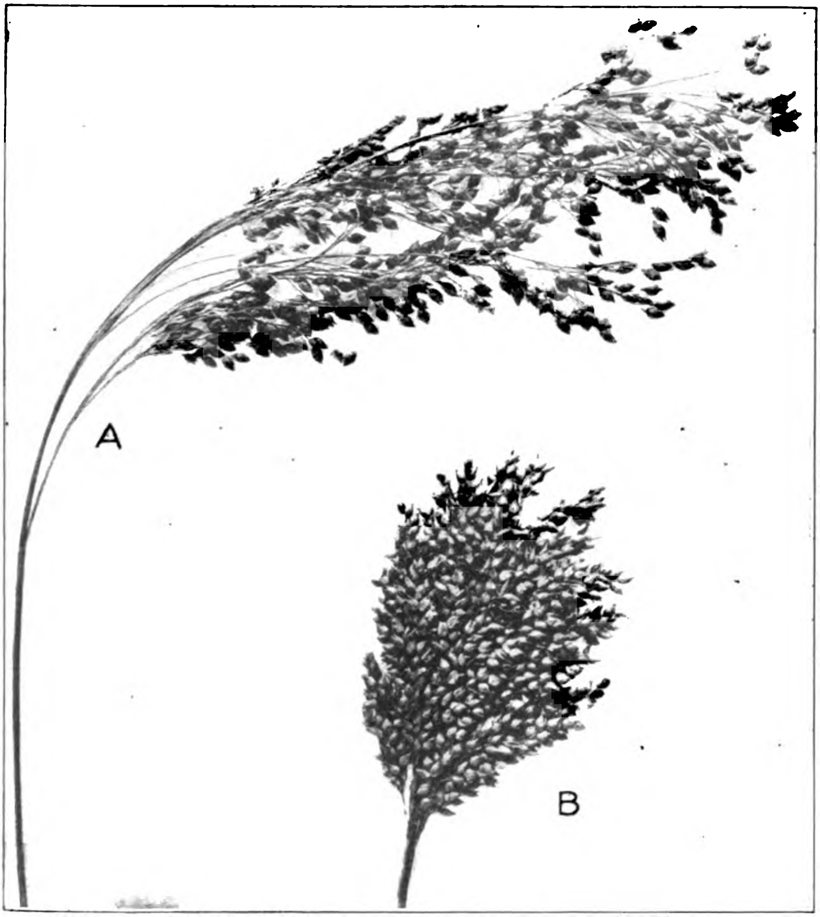

FIGURE 4.—A, Head of Black Voronezh proso, showing the loose one-sided type of head; B, Red Lump proso, showing the compact type of head

The Early Fortune, Yellow Manitoba, and White French varieties have been grown in the United States for many years. The White Ural, Tambov, Red Russian, Red Orenburg, Black Voronezh, Red Voronezh, and Yellow Sarepta varieties were first introduced into the United States from Russia by M. A. Carleton, of the United States Department of Agriculture, in 1899 and 1900. The Turghai variety was introduced from Russia by E. A. Bessey, of the United States Department of Agriculture, in 1903. The Red Lump proso was introduced from Russia by N. E. Hansen, of the South Dakota Agricultural Experiment Station, in 1898, while acting as an explorer for the United States Department of Agriculture. Professor Hansen also introduced the Hansen White Siberian variety from Siberia in 1913, when he was employed by the State of South Dakota.

The Black Voronezh has produced the highest average yields in extended experiments with proso varieties at Amarillo, Tex. It frequently yields well in other localities, but matures rather late. A head of this variety is shown in Figure 4. In Colorado, North Dakota, South Dakota, and Wyoming a variety known as Turghai has in general produced the highest average yields. A head of Turghai proso is shown in Figure 3. The Tambov and Red Russian varieties have yielded nearly as well. All three of these latter varieties are medium early in maturing and have yellowish or reddish brown seeds.

TABLE 1.—*Characters of the leading varieties of proso*

Varieties	Character of panicle, or head	Color of outer chaff	Color of seed hull	Season of maturity	Height of plants
White Ural	Spreading	Yellowish green	Creamy white	Early to midseason.	Short to midtall.
Hansen White Siberian.	do	do	Brownish yellow.	do	Do.
Tambov	do	Reddish green	Reddish brown	do	Do.
Red Russian	do	do	do	do	Do.
Turghai	do	do	Yellowish brown	do	Midtall to tall.
White French	Loose, one-sided	Yellowish green	Creamy white	Midseason to late.	Do.
Yellow Manitoba	do	do	Brownish yellow.	do	Do.
Red Orenburg	do	do	Reddish brown	Early to midseason.	Short to midtall.
Black Voronezh	do	do	Brownish black	Midseason to late.	Midtall to tall.
Red Voronezh	Compact, erect	do	Reddish brown	Early to midseason.	Short to midtall.
Yellow Sarepta	do	do	do	do	Do.
Early Fortune	do	do	do	do	Do.
Red Lump	do	do	do	do	Do.

The Yellow Manitoba and White French varieties mature too late to be of value in the northern Great Plains area, but yield well in favorable seasons and under humid conditions. The Early Fortune is the most common variety of the so-called red-seeded prosos. Because of its small growth and extremely early maturity this variety usually produces small yields. Some of the Early Fortune is grown in a mixture with Red Russian. The Red Lump variety is nearly identical with the Early Fortune, but the seeds have a slightly different color. A head of the Red Lump variety is shown in Figure 4. The Red Orenburg, Red Voronezh, and Yellow Sarepta are early red-seeded varieties of minor importance which have not produced large average yields. The latter two are apparently identical.

The white-seeded prosos are preferable for food purposes because the white hulls are not so noticeable in the meal or flour as are red or black hulls, and it is almost impossible to remove all the hulls before grinding. This is of no importance in stock feed, however. The early white-seeded varieties White Ural and Hansen White Siberian do not yield as well in South Dakota as the Turghai, Tambov, or Red Russian. At Brookings, S. Dak., in four years experiments the Tambov variety yielded 32 bushels per acre, Black Voronezh 31 bushels, and the Hansen White Siberian only 21.7 bushels per acre. At Cottonwood, S. Dak., the Tambov variety has a 4-year average acre yield 2.1 bushels higher than the Hansen White Siberian. At Highmore, S. Dak., in four years' experiments the Hansen White Siberian yielded only 11.3 bushels per acre, while during the same period the Turghai yielded 20.1 bushels, the Black Voronezh 16.9 bushels, and the Tambov 16.8 bushels per acre. At Newell, S. Dak., in three years' experiments the Hansen White Siberian produced an average yield of 26.5 bushels per acre, the White Ural yielding 30.7 and the Red Russian 32.6 bushels per acre. The White Ural thus yielded 4.2 bushels per acre more than the Hansen White Siberian. It is a few days earlier, has whiter hulls, and is thus preferable to the latter variety for food purposes. The White Ural variety is not now grown commercially. The Red Russian has outyielded all other varieties at Dickinson, N. Dak.

PREPARATION OF THE SOIL

The seed bed for proso should be moist, smooth, and rather compact, so that prompt germination will give the plants a chance to compete with weeds. If the land is weedy it should be disked and harrowed just before seeding. The harrowing also smooths and compacts the seed bed. Late spring plowing or breaking should be thoroughly disked and harrowed before seeding, as many nonuniform stands of proso are due to an uneven seed bed. Corn or potato ground should be disked and harrowed. Land on which a grain crop has failed should be disked and harrowed if weeds or scattering plants of grain remain, but if the field is clean no further preparation usually is necessary before seeding. Proso doubtless will produce the highest yields on summer-fallowed land or following a tilled crop, such as corn or potatoes, but such land can be more profitably sown to other grain.

METHOD OF SOWING

Proso should always be sown with a grain drill in order to get uniform stands with the least quantity of seed. It should be sown in about the same manner as flaxseed. Seeding in the regular drill rows, 6 to 8 inches apart, has produced higher yields than seeding in wider spaced rows and cultivating between them. At Newell, S. Dak., proso sown in 7-inch drill rows yielded 8.9 bushels per acre more than that sown in 21-inch rows. In a good seed bed three-fourths of an inch to an inch is deep enough to sow, and the depth should never be more than 1½ inches. In a sandy or a dry soil the seed may be sown deeper than in a moist, compact soil.

RATE OF SOWING

Proso should be sown at about the same rate per acre as flax. In the semiarid sections 20 to 50 pounds per acre is ample. At Akron, Colo., the highest yields of proso have been obtained from seeding 35 to 58 pounds per acre.

In the humid sections proso should be sown at the rate of 2 to 3 pecks per acre. It is usually not profitable to sow less than 15 pounds per acre under any conditions, because of the decreased yields. In sowing proso the drill should be adjusted as if to sow flax at the rate desired. Internal force-feed drills when adjusted to sow 2 pecks of wheat will sow about 33 to 35 pounds of proso per acre.

DATE OF SOWING

Proso will not germinate in cold soil. The plants are easily killed by severe frosts in the spring. Seeding should be delayed until the danger of frost is practically over. Profitable yields have occasionally been obtained from seeding as late as July 1 or even later, but this is not dependable in the Dakotas. Proso is easily injured by early fall frosts and does not mature seed well in cool weather. At Highmore S. Dak., the highest yields have been obtained by seeding about June 1. Fair average yields have been obtained by sowing between May 15 and June 15. At Akron, Colo., the highest yields have been obtained from seeding between July 1 and 15. Most varieties of proso require about 60 to 80 days from seeding to maturity. Seeding should be early enough to avoid early fall frosts. The date of seeding depends also on the supply of soil moisture, as it is not advisable to sow in a dry soil. A fair general rule is to sow proso from 2 to 4 weeks after corn is planted.

HARVESTING

Proso should be harvested when the seeds in the upper half of the heads are ripe. At this stage the plant is still green. If cut earlier there will be much immature seed and if cut later considerable seed will be lost from shattering. If cut too green, there is danger of the straw molding. Proso seed is easily shattered when ripe and the crop should be handled carefully to prevent loss. The binder is usually the best machine for cutting proso. If the plants are too short to bind, the crop can be cut with a mower and raked and shocked like hay, but more seed is shattered out by this method.

The bundles left by the binder should be placed in rather small or long and narrow shocks to prevent molding and to permit early drying. The crop should be removed from the field as promptly as possible in order to prevent loss and damage from birds and field mice, which seem to prefer proso to any other grain.

Proso can be harvested with a windrower and later threshed with a combine equipped with a pickup attachment.

THRESHING

The seed of proso is separated from the straw very readily with an ordinary threshing machine. Two rows of concave teeth usually are sufficient to remove all the seed. The cylinder should be run slowly enough to avoid the hulling of too much seed. The seed is easily cleaned in threshing by the use of flax or millet screens, but certain weed seeds, such as foxtail or pigeon grass, Russian thistle, and mustard, are difficult to remove.

USES OF PROSO

HUMAN FOOD

In certain portions of China, Russia, Siberia, and India, proso is a common article of food. The hulls are removed from the seed in a special machine designed for this purpose and the seed is then ground into a meal.

The meal is cooked into a mush, called " kasha " by the Russians. Proso meal makes an excellent thickening for soups. The South Dakota Agricultural Experiment Station reports that proso flour when mixed with four parts of wheat flour makes a satisfactory substitute for wheat flour. Digestion experiments with bread made from proso indicate that the carbohydrates are as well utilized as in other cereals, but that less than half of the proteins were digested.[3] The proso seed has an agreeable taste with a slight nutty flavor, different from other cereals, and is well liked by some people. It is not, however, any more palatable than other cereal products and therefore is not in any special demand as a food in the United States as yet. It is thought by some that it may be possible to develop certain products of proso as cereal foods in this country. As our present foods are selected largely according to habit and custom it would be necessary to educate the public to a demand for a new dish. There are no machines for hulling proso seed on a commercial scale in this country. For home use proso can be ground in a small coffee mill. The hulls then can be removed with a small fanning mill and the coarse meal and flour separated with sieves.

FEED FOR LIVESTOCK

The unhulled proso seed has a composition very similar to that of oats and is slightly higher in feeding value than oats when fed to livestock. Experiments conducted by the South Dakota Agricultural Experiment Station indicate that a bushel of proso weighing 56 pounds is necessary to produce the same gain on hogs as a bushel of barley weighing only 48 pounds and that it produces a greater percentage of lean meat and a softer fat on hogs than does barley. Recent experiments in Colorado indicated that proso was about equal in feeding value to corn and barley for pigs and lambs. Proso is eaten very readily by all kinds of livestock but should be ground before being fed. It is relished by poultry, and it is a common ingredient in commercial birdseed. Proso can be fed to chickens in unthreshed bundles, as the seed is shelled out easily by scratching.

Proso is not a hay crop and should not be grown for that purpose. The foxtail millets or other crops will produce more hay or roughage, and proso hay is of poor quality. While the hay may be eaten it is not relished, and considerable waste will result. An examination of the coarse hairy stems of proso shows clearly why stock do not like it.

Proso can be made into silage, but the yields are too small to make it a profitable silage crop.

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[3] LANGWORTHY, C. F., and HOLMES, A. D., EXPERIMENTS IN THE DETERMINATION OF THE DIGESTIBILITY OF MILLETS. U. S. Dept. Agr., Bul. 525, 9 p. 1917. Out of print, but may be consulted in libraries.

Seed dealers frequently make the statement that "the crop is harvested while the plant is still green, so that the straw makes valuable hay." It is true that the stems, leaves, and chaff are still rather green at the time the seed ripens, but, as previously stated, they are not liked by stock. The straw may be fed, however, without injury to livestock.

DISEASES AND PESTS OF PROSO

The only disease of any consequence which attacks proso is smut. This can be controlled by the standard formaldehyde treatment, as applied to wheat.

Chinch bugs attack proso as well as other millets and other grain crops. The same methods of destruction are applicable to this pest on proso as when they injure other spring grains.

Birds, gophers, and field mice are very destructive to proso after the seed is ripe. Harvesting as early as possible and prompt threshing or stacking will prevent much of the loss.

WEIGHT OF PROSO PER BUSHEL

A legal weight for millet seed of 50 pounds per bushel has been established by several of the States, but there is no standard for the United States. Proso is regarded as a millet in these laws. The average weight of clean plump proso seed is about 56 pounds per bushel, and this is the weight used by the United States Department of Agriculture in determining the acre yields.

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DRY FARMING IN WESTERN SOUTH DAKOTA

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FARMERS' BULLETIN 1163

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 19

GRAIN CROPS in western South Dakota, in the average results of a series of years, show yields that should be profitable; but a stable agriculture based upon grain production alone has not been established. This is owing to the fact that the average is made up of exceedingly heavy yields in a few years and low yields or failure in other years rather than fairly good yields each year. Grain farming has not been able to withstand the reverse of the unfavorable years, which may appear in succession, and to realize the profits of the good years.

The United States Department of Agriculture, since 1908 at the Belle Fourche Field Station, near Newell, and since 1912 at the Ardmore Field Station, has been conducting thorough investigations of methods of crop production in South Dakota. The results of these investigations show that the high fluctuation of yields, due to fluctuating rainfall, can not be sufficiently overcome by cultural methods to change the problem materially. These results and the experience of farmers who have succeeded indicate that the most favorable conditions for grain production are found when combined with or subordinated to stock production.

The system and methods recommended are (1) keeping live stock to the capacity of summer pasture and winter feed, (2) the growth of cultivated annual crops (corn and sorghum) for winter feed, and (3) the growth of small grains following the corn without plowing. This system may be modified as local or individual conditions warrant the growth of alfalfa for hay or seed, or the growth of a larger acreage of wheat or other grains.

DRY FARMING IN WESTERN SOUTH DAKOTA.

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AGRICULTURAL CONDITIONS.

WESTERN SOUTH DAKOTA is largely a dry-farming country. With the exception of the Black Hills and a narrow belt of land adjacent to and influenced by them, the whole section lies within a region normally deficient in rainfall. A certain part of this territory is irrigated, and more will no doubt eventually be reclaimed, but most of it must always remain a dry-farming region.

Attempts to make this section of South Dakota a strictly crop-producing region have been unsuccessful. The settlement of this country has generally been made after a series of good years had created an exaggerated idea of its crop possibilities. Most of the original settlers tried to make a living by crop production, and almost all of them failed and left the country. Only those who turned to the raising of live stock as their principal industry have been able to remain.

While crop production alone has not been successful, the growth of a certain proportion of crops is necessary to the best development of the live-stock industry. This bulletin in reporting the results of studies of methods of crop production indicates a way in which the two can be combined to make each successful. It is based upon the results obtained on the dry-farming unit of the Belle Fourche Experiment Farm, near Newell, S. Dak., established in 1908, supplemented by those of the Ardmore Field Station, established in 1912. At both stations all the adapted crops have been under trial each year under all the combinations and methods likely to be practiced or offering a possibility of success.

TOPOGRAPHY OF THE COUNTRY.

Most of western South Dakota is a Plains region. There are portions that are too rough for cultivation, but by far the larger part is physically suited to the raising of crops. Much of it consists of rolling hills whose slopes are generally not too steep to be cultivated. Economic conditions that will decide how much of the land can be profitably cultivated, rather than the topography of the country, will determine the area of land devoted to crops.

SOILS.

The soils of western South Dakota vary from almost pure sand to a very heavy clay, or "gumbo." The Pierre clay, or "gumbo," soil constitutes about one-third of the area of South Dakota west of the Missouri River. The Belle Fourche Experiment Farm, near Newell, is situated on this type of soil, and the results at this station are to be applied to this soil in particular. It is on soil of this type that dry farming is the most difficult and that crop production is the least successful. Both the expense of working the soil and the fact that crops show less drought endurance on this heavy soil than on lighter soils contribute to this result. So far as soil conditions are concerned, the lighter the soil the more certain crop production should be, provided the soil is not so light that soil blowing becomes a factor. The lighter soil will probably not produce as high yields as the heavy soil in favorable years, but will endure more drought and produce better yields in years of partial failure. Average yields obtained at Newell are doubtless lower than would be obtained in more favorable soils in western South Dakota.

The station at Ardmore is located in a soil of heavy clay type, but deeper and somewhat lighter than the "gumbo" of the station near Newell.

CLIMATE.

The average annual precipitation of western South Dakota, exclusive of the region influenced by the Black Hills, varies from 13 to 18 inches. At both Newell and Ardmore about 65 per cent of the total precipitation occurs during the five months from April to August, inclusive. The precipitation during the growing season, like the annual precipitation, is variable in both quantity and distribution. Both of these factors are of the highest importance in determining the area of crop production. Low seasonal rainfall is usually accompanied by high evaporation and possibly by unfavorable temperatures and hot winds. The same may be true of a seasonable precipitation normal in quantity but not well distributed. A well-distributed seasonal rainfall of average or more than average amount is usually accompanied by favorable growing conditions.

Only in exceptional years is the precipitation high enough and sufficiently well distributed to allow all crops to mature without their growth being checked to some extent by drought. Likewise it is rare for any year to be so dry that complete failure of all crops occurs.

In most years there is drought injury, varying in extent with the amount and distribution of the precipitation and with the intensity of other climatic factors. This injury seldom affects all crops equally. A complete failure of small grains, which make their growth early in the season, may occur in a year when good yields of late-growing cultivated crops are obtained, or a good yield of small grain may be secured in a year when cultivated crops do not do well.

The distribution of rain through the growing season is usually the deciding factor in determining which crops will be successful in any given year. The fact that one crop may do well in a year when another crop fails tends to make some diversification of crops necessary, in order that complete failure may be avoided as far as possible.

The amount and the distribution of the precipitation are well shown in Table I, compiled from the records of the Newell station. The precipitation at Ardmore is somewhat higher, the average for the 7-year period from 1913 to 1919, inclusive, being 17.43 inches, or 2.50 inches more than the average at Newell for the same years.

TABLE I.—*Precipitation at Newell, S. Dak., for the 12-year period from 1908 to 1919, inclusive.*

[Data in inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1908	0.20	0.19	1.65	1.16	3.95	1.47	1.26	0.62	0.52	2.03	0.20	0.91	14.16
1909	.17	.23	.19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	12.55
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	12.53
1914	T[1]	1.00	.29	1.09	2.22	2.09	1.34	1.12	.35	1.77	0	.43	11.70
1915	.92	1.01	.16	2.58	2.32	4.74	5.74	.44	1.26	1.25	.43	.17	21.02
1916	.36	.23	.98	.64	3.17	2.19	2.01	2.02	.20	.99	.33	.28	13.40
1917	.92	.74	.27	2.51	3.71	.97	.80	1.67	.35	.46	T	.92	13.32
1918	.99	.64	.81	2.40	1.60	1.17	3.41	2.99	3.08	.22	.15	.85	18.31
1919	.04	.57	.87	2.14	1.14	.35	2.59	1.02	1.20	2.49	1.22	.62	14.25
Average	.44	.48	.66	1.47	2.33	2.00	2.11	1.36	1.48	1.08	.36	.54	14.31

[1] T=trace.

CROP PRODUCTION.

Water stored in the soil at seeding time is used by the crops, and to the extent to which it is needed and is able to supplement the rainfall may determine the yield, but in this region it is not sufficient in itself to produce crops. Production is dependent upon the rainfall of the season in which the crops are growing. It is consequently impossible to tell from the character of the winter or from the amount of precipitation before seeding what the chances of success with the different crops may be.

Thus, the choice of crops, aside from winter wheat, in any given year should not be influenced to any great extent by conditions before seeding. The best farm practice is to select the crops that have shown the best average results for a number of years and devote a certain area of land to these each year rather than to try to base the acreage to be devoted to crops and the kind of crops to be grown upon conditions prevailing before seeding in any year.

Successful crop production in western South Dakota must embody the following: (1) The selection of crops best adapted to the locality and the best varieties of these crops, (2) the use of cultural methods that will give the greatest return for labor in the production of these adapted crops, and (3) the adoption of a system of farming in which crop production supplements the other lines of farm activities.

ADAPTED CROPS.

The crops adapted to western South Dakota consist principally of small grains, cultivated crops, and pasture and hay crops. These will be considered separately.

SMALL GRAINS.

The production of small grains at both the Belle Fourche and the Ardmore Field Stations has been uncertain in the extreme, though in the average of a series of years most grain crops have shown profitable yields. Analysis of the results shows that the fairly good average yield is the result of very high yields in good years and low yields in other years rather than of fairly good yields each year. The average yields of wheat, oats, barley, winter wheat, corn, and sorghum at the Belle Fourche Field Station, near Newell, and at the Ardmore Field Station are shown in Table II. The yields given are the averages of all methods under trial and represent an approximately equal number of the better and poorer yielding methods. While they are probably above the averages obtained by all farmers, it ought to be possible for farmers using only the best methods to equal or exceed them.

The yearly results in this table show why grain farming in this section has not been successful. The average yield of wheat at the Belle Fourche Field Station has been 13.4 and at Ardmore 16.7 bushels per acre. If it were possible to obtain these yields of wheat each year, wheat raising could be made a profitable type of farming. However, in 7 of the 11 years at Belle Fourche and in 5 of the

8 years at Ardmore the yield of wheat has been considerably below these averages, and in these years wheat has been grown either at a loss or at a very small profit. Practically all the profit has been obtained in two years of very high production. As many as three years of nearly complete failure have occurred successively. This explains why wheat production has been an unstable type of farming.

TABLE II.—*Yields of wheat, oats, barley, corn, and sorghum at the Belle Fourche and Ardmore (S. Dak.) Field Stations for certain years in the 11-year period from 1909 to 1919, inclusive.*[1]

Station and crop.	1909	1910	1912	1913	1914	1915	1916	1917	1918	1919	Average.
Belle Fourche:											
Wheat..............bushels..	28.7	2.5	0	10.8	10.1	57.6	17.3	7.4	11.9	0.9	13.4
Oats....................do....	60.9	6.8	8.2	23.9	26.3	125.6	33.4	17.1	23.3	2.3	29.8
Barley..................do....	32.2	3.0	.7	10.1	9.5	72.2	31.0	22.9	14.6	1.3	18.0
Winter wheat..........do....	28.9	1.8	0	21.3	18.2	36.2	12.7	3.8	27.1	2.0	13.8
Corn {Grain..............do....	19.3	.6	21.9	8.6	.5	44.5	32.5	20.4	30.0	.3	16.2
Corn {Stover..........pounds..	3,305	2,839	2,623	986	1,115	2,785	2,198	1,969	2,977	235	1,912
Sorghum, stover........do....	5,920	3,360	4,100	3,400	1,725	6,450	9,650	3,300	7,700	0	4,146
Ardmore:											
Wheat..............bushels..	......	......	7.3	2.6	0	46.5	21.1	9.2	35.0	11.6	16.7
Oats....................do....	......	......	15.1	7.0	0	84.5	39.8	15.2	65.1	22.4	31.1
Barley..................do....	......	......	3.2	4.3	0	52.9	23.4	5.3	39.9	8.6	17.2
Winter wheat..........do....	......	......	......	1.4	0	33.9	31.3	7.2	19.4	18.3	15.9
Corn {Grain..............do....	......	......	22.1	0	0	38.2	22.1	13.7	22.3	9.2	16.0
Corn {Stover..........pounds..	......	......	1,640	927	1,018	3,669	3,025	1,410	2,110	1,524	1,915
Sorghum, stover........do....	......	......	......	......	1,665	12,256	6,240	3,100	6,700	3,964	5,654

[1] No yields were obtained at the Belle Fourche Field Station in 1911 on account of drought. The average yield given is for the 11-year period.

Wheat raising alone is not successfully maintained where in two years out of three it must be carried on at a loss or at a very small profit. It can, however, be carried on profitably in connection with live-stock production, provided it can be handled in such a way as to require a minimum of labor and expense.

The same is true of oats and barley. Their yields have been relatively about the same as that of wheat, and the drought resistance of the three has been practically the same. Choice between these three crops must depend primarily upon individual conditions that determine which crop can be most profitably disposed of.

Winter wheat survives the winter in only a small portion of western South Dakota. Where it endures, it usually produces a higher yield than spring wheat. In the section to which it is adapted it is more profitable than spring wheat. When winterkilling does take place, the land can be reseeded to spring wheat or some other crop without any further expense than seed and seeding. When there is not sufficient moisture in the soil in the fall to insure germination of the seed, the planting of winter grains is not advisable.

Winter rye has not been as profitable as winter wheat in the section where winter wheat does well. It is, however, more hardy and will endure the winter in any section of the State. Over most of western South Dakota it is at least as profitable as the spring grains.

It ripens earlier in the season and consequently often escapes periods of drought that affect spring-seeded crops. For this reason it is a more dependable crop than the spring grains, though its yield does not compare favorably with theirs in years of high production.

The yields of flax at these stations have not been high. Flax has been generally grown as a sod crop on new breaking, and in this connection has given poor yields. Flax on old ground or upon land broken the previous summer has given better results, but even then has not been as good as other grain crops. It is particularly adapted for growth where a cash crop is desirable and where a long haul to market is necessary. Its high price in proportion to its bulk makes it a valuable crop in this connection, even though the weight of the product per acre is relatively smaller than that of other grains.

The best varieties of these different grain crops and the best time and rate of seeding recommended as a result of extensive tests conducted by the Office of Cereal Investigations of the Bureau of Plant Industry are stated in Farmers' Bulletin 878, entitled "Grains for Western North and South Dakota,"[1] as follows:

Varieties.—Winter wheat (in the vicinity of the Black Hills), Kharkof, Turkey; spring wheat, Kubanka, Marquis; oats, Kherson, Sixty-Day; barley, White Smyrna, Hannchen; rye, North Dakota No. 959, Swedish; flax, North Dakota No. 155, Damont.

Time of seeding.—Sow spring wheat and oats as early as the land can be put in good condition, barley after wheat and oat seeding is finished, and flax about May 1. Sow winter wheat and winter rye in late August or early September in North Dakota and in September or early October in South Dakota.

Rate of seeding.—The best rates of seeding are as follows: Spring wheat, 4 pecks per acre; winter wheat, 3 to 4 pecks per acre; oats and barley, 5 to 6 pecks per acre; flax, 20 to 30 pounds per acre.

CULTIVATED CROPS.

Corn is the cultivated crop grown most generally in western South Dakota. There are varieties that will ripen in all parts of this section. A yield of grain can not be secured every year, but a yield of fodder is fairly certain. Sorghum is the only other crop that offers possibilities of competing with corn as a coarse feed crop in this section. Table II presents the average annual yields of both corn and sorghum at both the Belle Fourche and the Ardmore Field Stations. This table shows that at each station corn has produced a profitable crop of grain in more than half the years. At Ardmore there has been some crop, at least of stover, every year, but at Belle Fourche there was complete failure in 1911 and a failure from most methods in 1919. In both of these years the ground was so dry at corn-planting time that the seed did not germinate. Sorghum failed in those years for the same reason.

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[1] By F. Ray Babcock, John H. Martin, and Ralph W. Smith.

The greatest value of corn as a dry-land crop is its ability to produce a fair yield of stover even in dry years. Corn fits in admirably with the raising of live stock and can be depended upon to produce winter feed for them in most years so dry that the growth of grass on the prairie is scant and opportunities for cutting hay are limited. In addition to this, corn in more favorable years produces a fairly good yield of grain. The combined value of the grain and stover tend to make corn the most profitable dry-land crop in this area. As the number of stock in the section increases and the area of land where hay can be cut becomes smaller, farmers will be more and more dependent for their winter feed upon crops like corn that produce a large yield of rough feed per acre.

Sorghum produces a higher yield of stover per acre than corn over most of western South Dakota, and the stover is more palatable. It does not appear likely, however, to replace corn to any considerable extent in this section. The combined value of the grain and stover of corn is greater than the stover value of sorghum. This, together with the fact that corn is easier to produce, makes it seem certain that corn will continue to be the leading cultivated crop. It is worthy of note, however, that in the years 1910, 1913, and 1914 at Belle Fourche and 1914 and 1919 at Ardmore, when the yield of ear corn was low, sorghum was the more valuable crop. The yield of sorghum in these years was proportionately greater than in more favorable years. A portion of the corn acreage could well be replaced by sorghum as an insurance against failure of the feed crop in unfavorable years.

The varieties of corn best suited to western South Dakota vary with the locality. Near the northern part of the State only very early corn will mature. In the central and southern portion the earlier Dent corns, such as Northwestern and Payne White Dent, have been most successful. In many places some unnamed varieties have been grown in restricted localities for a number of years. In most cases adapted acclimated varieties like these are as valuable as the standard varieties that are more widely known.

Only the sweet sorghums are adapted for growth as far north as South Dakota. Minnesota Amber, Dakota Amber, and Red Amber are the most promising varieties.

PASTURE AND HAY CROPS.

At least in the "gumbo" soils of western South Dakota the growth of pasture crops has not been and is not likely to be practiced. The expense of preparing the ground and seeding a pasture crop, together with the fact that a comparatively large acreage is required for each animal pastured, makes the initial cost almost prohibitive.

Alfalfa and brome-grass offer possibilities as hay crops. The yield of feed is much less per acre than that of corn and similar crops, but there is an advantage in that they do not need to be planted each year. Alfalfa at least will endure for an indefinite number of years. It will produce a cutting practically every year, though the growth may be checked by drought before the alfalfa comes into bloom. In only one year, 1915, have two cuttings been produced at Belle Fourche. In one year, 1911, the crop was a total failure. Alfalfa is particularly adapted for growth along streams or on bottom lands where the ground water is within reach of the roots. Under conditions like this it will make two or three cuttings each year. Brome-grass is particularly adapted to places that receive considerable run-off. In such situations it can be depended upon to produce one good-sized crop of hay each year until it becomes sod bound. The greater feeding value of alfalfa and the fact that it produces nearly as much hay as brome-grass and does not become sod bound make it much more valuable as a hay crop.

In addition to its value as a forage crop, alfalfa is often of great value as a seed crop. In years when seed production is good, the value of the seed is usually far greater than that of the forage. When a seed crop is obtained, the straw from which the seed has been separated is readily eaten by stock and has a greater nutritive value than grain straw.

The ability of alfalfa to produce seed depends to a great extent upon the type of soil upon which it is grown. On the heavy clay soils, like that at Belle Fourche, alfalfa seldom produces seed after it has once been established, even when grown in cultivated rows. The plant generally begins to suffer from drought before it comes into full bloom, and little seed is formed.

On lighter soils alfalfa suffers less severely from drought and produces seed in most years if it is grown in cultivated rows or broadcast with a very thin stand. Culture in rows is the surest method of producing seed, but the expense of cultivation reduces the profit from this method to some extent. Practically the same forage yield is secured from alfalfa in cultivated rows and that sown broadcast.

On soils where ground water is within reach of the roots a seed crop is obtained nearly every year. Where this condition exists no advantage is to be gained by growing in cultivated rows. Either the first or second cutting may be left for seed. The first cutting is a little more certain to produce seed than the second, and the seed is sure to ripen without danger of frost injury. When the second cutting is left for seed, a cutting of hay is obtained in addition to the seed crop.

With the exception of land where the ground water can be reached by the roots, alfalfa seed production is not sufficiently certain to become a part of any definite farming system. However, on the lighter soils of western South Dakota a certain part of the land can be planted to alfalfa to very good advantage. In years of good seed production the alfalfa can be saved for seed. In years when it seems apparent that little seed will be formed the crop can be cut for hay. Used in this way, it will be valuable in all years except those of complete failure.

The variegated alfalfas—Grimm, Baltic, and Cossack—have shown slightly better yields and greater hardiness than common alfalfa.

CULTURAL METHODS.

The cultural methods that have been under trial consist of spring plowing, fall plowing, disking, listing, subsoiling, summer tillage, and the plowing under of green-manure crops.

The number of tillage operations required for preparing the land for a crop varies a great deal with these different cultural methods. The time at which the labor must be performed likewise varies. The tillage operations involved in each method of cultivation and the time at which they may be best performed are as follows:

Spring plowing for all small grains should be done as early as weather conditions will permit. Plowing to a depth of 4 to 6 inches is advisable. The land should be disked before it has a chance to dry out and harrowed at least once after plowing. Spring plowing for corn may be delayed until after small grains are seeded.

Fall plowing may be done at any time after harvest. From 5 to 8 inches constitutes a good depth. As the land is usually dry in the fall, it is best to leave it rough until spring. A double disking and a harrowing in the spring are all the preparation necessary before seeding small grains. Where a later seeded crop is to be planted, additional cultivation may be required in order to keep the land free from weeds until seeding. Fall plowing offers a better distribution of labor than spring plowing.

Disking without plowing at the Belle Fourche and Ardmore stations has been practiced only for small grains and only on land where an intertilled crop has been grown. Double disking and harrowing in the spring are all the preparation required before seeding.

Listing for small grains may be done at any time after harvest. The lister should be run a little deeper than for planting corn, and the furrows should be about the same distance apart as for corn. The land may be left rough over winter and worked down level in the spring. Normally, two diskings and a harrowing are required. Listing for corn is usually done with a lister planter. No cultivation before planting is required where corn is planted in this manner.

Subsoiling is done at the same time as fall plowing. The land is plowed with an ordinary plow to a depth of 8 inches, and a subsoil plow is run in alternate furrows to an additional depth of 8 inches, making a total depth of 16 inches. As the time and labor necessary for plowing with the subsoil plow are at least as great as for original plowing, the cost of the whole operation is practically that of two plowings. The spring cultivation needed for subsoiled land is the same as for land given an ordinary fall plowing.

Land to be summer-fallowed should be plowed about 8 inches in the spring or early summer, worked down immediately after plowing, and kept free from weeds during the rest of the season. This usually requires at least two diskings and several harrowings. In addition to the great labor required, it involves the loss of the land for a year. Consequently, it is an expensive method of land preparation.

Green manuring is the most expensive method that has been tried. It involves the preparation of land for the green-manure crop, the cost of seed and seeding, the plowing under of the green-manure crop, and the keeping of the land free from weeds the rest of the season. Usually two plowings, at least two diskings, and two or more harrowings are required. The loss of the land for a year is also an item of expense in preparing land by this method.

The different crops vary in their response to these cultural methods. For this reason grain crops, cultivated crops, and hay crops are considered separately.

Small grains.—The results at Belle Fourche indicate clearly that the most profitable crops of grain are produced by the cheaper methods of soil preparation. Grain on disked corn land or on disked land where some other cultivated crop has been grown has shown the highest net profit of any method of soil preparation tried. This is due largely to the low cost of production, but partly to the fact that disked cultivated land has generally produced yields above the average. The yields of wheat, oats, and barley on disked corn land have been higher than the yield of the same crops on spring or fall plowed corn land. In other words, plowing corn land either in the spring or fall has been accompanied by an actual loss in yield, as well as by the increased cost of production due to the plowing. It must be borne in mind that the corn ground had been kept free from weeds. If weeds had been allowed to grow, the results probably would not have been so favorable. With the corn ground kept clean the production of grain on the disked corn land is by far the most profitable method of production that has been tested.

Spring and fall plowing are about equal as methods of land preparation for grain. Practically the same amount of labor is necessary for the preparation of a seed bed, and when seeding is done at the same time the yields produced are nearly the same. Fall plowing can be done at a time when work is not so pressing; consequently, it has an advantage over spring plowing in that respect. As seeding can be started as early as plowing, fall-plowed land can be seeded earlier than land that must be plowed in the spring. This consideration becomes most important in seasons when unfavorable weather conditions hinder spring work. This is a decided advantage for fall plowing, because early-seeded crops mature earlier and as a result often escape periods of drought that injure later seeded crops. However, if the conditions in the fall are such that plowing can not be done, a farmer may do his plowing in the early spring and be assured of practically the same returns as if the land had been plowed in the fall, provided seeding is not unduly delayed. Plowing is more expensive than disking in preparing land for grains. When small grains follow corn, better yields are obtained by disking. Plowing grain stubble is recommended for use only in the sections of western South Dakota where grain growing is most successful and where the desired grain acreage is greater than the area devoted to corn. Over the section represented by the station near Newell, the yields are so low that the production of grain, other than on disked corn land, is more likely to result in loss than in profit.

The yields of grain on listed land compare favorably with those on plowed land. The cost of production on listed land is slightly lower, so the net return is a little higher. The difference in return however, is not great enough to justify the purchase of any special equipment for growing grains on listed land.

The more intensive methods of cultivation, such as fallowing and plowing under green-manure crops, have not proved profitable in grain production. The yield of grain has been increased both by fallowing and by the plowing under of green-manure crops. But in few cases has the increase been large enough to pay for the added expense. In years of high rainfall other methods are as good; in years of low rainfall all methods fail; only in some years of partial failure do these methods show to advantage. On an average, their use over the period covered by the experiments has resulted in a smaller profit for fallowing than for cropping each year and a net loss for plowing under green-manure crops.

Subsoiling and deep tillage have neither increased nor decreased yields to a measurable extent. They have simply added to the cost of producing grains without adding to the value of the crops produced. Consequently, these practices have been less successful than cheaper methods of cultivation.

Intensive tillage methods can not be expected to pay in a section where the net profits per acre are low and where yields are not greatly increased by their use. The same amount of labor distributed over more acres would be a more profitable investment.

Subsoiling, green manuring, and fallowing are not recommended as general practices for any section of western South Dakota.

Cultivated crops.—Spring and fall plowing have given about equal results as methods of soil preparation for corn. Fall plowing requires a little more cultivation in that a certain amount of spring cultivation is necessary in order to keep the land clean until the corn is planted. It has a slight advantage in that the corn usually comes up a little sooner and matures just a little earlier. There is no great difference in yields, and the farmer may arrange to do his plowing at any time previous to planting without materially affecting the yield.

Listing for corn has given lower yields than spring or fall plowing. The low cost of land preparation, however, makes the net profit per acre secured fully as high. In spite of this, listing is not likely to meet with favor in western South Dakota. Corn on listed land has a tendency to come up a little more slowly and to mature a little later than corn on plowed land. There is also some difficulty in securing a stand.

The more intensive methods of tillage have shown less response with corn than with small grains.

Fall plowing has been superior to spring plowing as a method of land preparation for sorghum. The difference has been largely due to stand. Spring-plowed land of the heavy clay type can not always be worked down to form a good seed bed for sorghum, because of its tendency to remain lumpy until mellowed by rains. In seasons that are dry between plowing and planting time, the fine seed bed necessary to secure a good stand of sorghum can not be obtained.

Hay crops.—Hay crops, such as alfalfa and brome-grass, are not adapted for use in rotations. They should be seeded in spring or early summer on land fall plowed, worked down to form a solid seed bed in spring, and kept free from weeds until seeding. After a stand of these crops has been obtained, they should not be plowed up, but should remain intact as a hayfield so long as the production remains good. Brome-grass may be pastured to good advantage for several years after it becomes so sod bound that it no longer produces a profitable yield of hay. Crops following alfalfa and brome-grass are usually poor, on account of the extremely dry condition in which the soil is left.

THE BEST SYSTEM OF FARMING.

The system of farming that offers the greatest possibility of a permanent agriculture for western South Dakota is one in which crop production is combined with the raising of live stock. Crop production alone can not be depended upon for a successful type of farming, as the cash crops, such as small grains, are subject to failure and the margin of profit is low. The more certain crops, such as corn stover and sorghum, can not be grown with profit unless fed near where they are produced. Their bulky nature prevents long hauls, and their sale price is far below their feeding value. The production of live stock alone is likewise subject to limitations. The most prominent of these is the question of winter feed. In dry years the growth of grass on the Great Plains is scant, and the quantity of hay that can be cut is limited. Unfortunately the live stock need the most land for pasture in the particular seasons when the acreage that must be cut for hay must be extended if an adequate supply of winter feed is to be obtained. The best way to meet this condition is to grow some annual crop, such as corn, that produces a comparatively large bulk of rough feed per acre.

The system of farming that suggests itself is as follows: (1) The production of live stock up to the limit of pasture in dry years, (2) the planting of an acreage of corn sufficient to meet the winter demands of the stock to be carried over, and (3) the production of small grain on the corn land.

The limit of live-stock production for any one farmer lies primarily in the area of pasture land he has after an acreage sufficient for growing crops has been set aside. The number of live stock that should be kept should be limited by the extent of pasture available in a dry year rather than by that of a favorable season. It is better to undergraze land in good seasons than to overgraze it in years of drought. The carrying capacity of different sections varies with the native vegetation. What the carrying capacity of any particular section is must be determined by observation and experience.

Corn stover offers a solution of the question of winter feed. As has been shown in considering corn and sorghum, they can be practically relied on to furnish the rough feed each year. Ear corn is produced in paying quantities in more than half the years, and when obtained it can be well utilized either for feed or for sale. Since corn does well on either spring or fall plowing, the work preparatory to planting can be done at the time when it interferes least with other farm work. The acreage of corn and sorghum grown should be sufficient to insure winter feed for the live stock to be carried over. The acreage should be fixed by the quantity necessary for winter feed in years when the production of stover is not high. In years of extra-heavy production the excess feed can be carried over or the number of stock increased for winter feeding.

While corn and live stock must form the basis of a permanent agriculture in this section, grains can be grown in connection with them as a speculative crop, with the chances of profit very good and the chance of total failure low. The corn ground provides one of the best preparations for small grains, on which they can be grown at a very low cost. Their yield, consequently, does not need to be heavy in order to be profitable. In years of high production they are very profitable. The land planted to corn in one year may be planted to small grain the next without expense other than disking, harrowing, seed, and seeding. In years when the conditions favor grain production, the value of the grain crop far exceeds the cost of production. In years when it seems apparent that no grain will be produced, the small-grain crops may be cut for hay and a supplemental supply of winter feed thus secured. This will make the grain crops of value in seasons when their production for grain is a failure. As has been stated, the corn should be kept clean. The cost of keeping the corn free from weeds is more than made up in the added value of the following crop. The kind of small grain to be raised must depend upon the needs of the individual farmer.

With modifications, this system of farming should be adapted to any section of western South Dakota. In places where grain does well the acreage of small grains may exceed the corn acreage. The extra acreage of small grain will then be grown on either spring or fall plowing following small grain. On farms where particular land conditions, such as land along streams, favors the growth of alfalfa and brome-grass the acreage of corn grown may be reduced. With modifications to meet special conditions, such a combination of crop growing with live-stock production holds promise of forming the basis of a stable system of farming for western South Dakota.

The climatic records available cover a much longer period than those of crop production. They show that such extreme years as 1911 are very infrequent. Such years, as well as less extreme ones like 1919, may be provided against in part by a liberal carry over of surplus feed from years of heavy production. They must be met in part by the importation of feed and in part by the temporary reduction of herds and flocks. The essential thing is that farms be so capitalized that they can stand the strain of such reverses and continue as going concerns prepared to secure the returns of the good and the average years.

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A1.9: 1163. Revised

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1163

DRY FARMING IN WESTERN SOUTH DAKOTA

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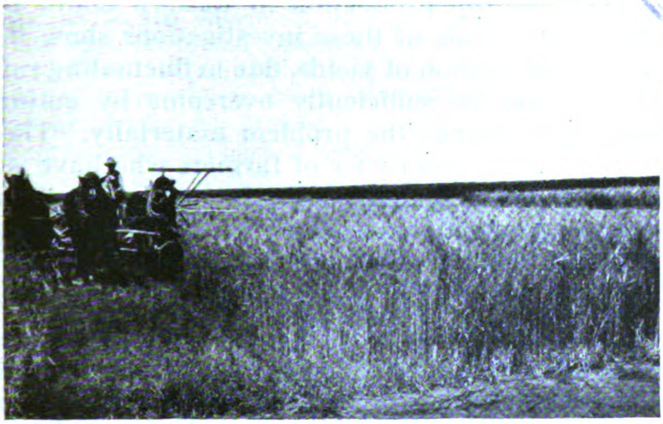

GRAIN CROPS in western South Dakota, in the average results of a series of years, show yields that should be profitable; but a stable agriculture based upon grain production alone has not been established. The average is made up of exceedingly heavy yields in a few years and low yields or failure in other years, rather than fairly good yields each year. Grain farming has not been able to withstand the reverses of the unfavorable years, which may appear in succession, and to realize the profits of the good years.

The United States Department of Agriculture, since 1908 at the Belle Fourche Field Station, near Newell, and since 1912 at the Ardmore Field Station, has been conducting thorough investigations of methods of crop production in western South Dakota. The results of these investigations show that the high fluctuation of yields, due to fluctuating rainfall, can not be sufficiently overcome by cultural methods to change the problem materially. These results and the experience of farmers who have succeeded indicate that the most favorable conditions for grain production are found when combined with or subordinated to stock production.

The system and methods recommended are (1) keeping livestock to the capacity of summer pasture and winter feed, (2) the growth of cultivated annual crops (corn and sorgo) for winter feed, and (3) the growth of small grains following the corn without plowing. This system may be modified as local or individual conditions warrant the growth of alfalfa for hay or seed, or the growth of a larger acreage of wheat or other grains.

Washington, D. C. Issued September, 1920; revised November, 1926

DRY FARMING IN WESTERN SOUTH DAKOTA

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AGRICULTURAL CONDITIONS

WESTERN SOUTH DAKOTA is largely a dry-farming country. With the exception of the Black Hills and a narrow belt of land adjacent to and influenced by them, it lies within a region normally deficient in rainfall. A certain part of this territory is irrigated, and more will no doubt eventually be reclaimed, but most of it must always be dry farmed.

Attempts to make this part of South Dakota a strictly crop-producing section have been unsuccessful. The settlement of this country has generally been made after a series of good years had created an exaggerated idea of its crop possibilities. Most of the original settlers tried to make a living by crop production, and almost all of them failed and left the country. Only those who turned to the raising of livestock as their principal industry have been able to remain.

Although crop production alone has not been successful, the growth of a certain proportion of crops is necessary to the best development of the livestock industry. This bulletin, in reporting the results of studies of methods of crop production, indicates a way in which the two can be combined to make each successful. It is based upon the results obtained on the dry-farming unit of the Belle Fourche Field Station, near Newell, S. Dak., established in 1908, supplemented by those of the Ardmore Field Station, established in 1912. At both stations all the adapted crops have been under trial each year under all the combinations and methods likely to be practiced or offering a possibility of success.

TOPOGRAPHY

Most of western South Dakota is a Plains section. There are portions that are too rough for cultivation, but by far the larger part is physically suited to the raising of crops. Much of it consists of rolling hills whose slopes are generally not too steep to be cultivated.

Economic conditions that will decide how much of the land can be profitably cultivated, rather than the topography of the country, will determine the area of land devoted to crops.

SOILS

The soils of western South Dakota vary from almost pure sand to a very heavy clay, or "gumbo." The Pierre clay, or "gumbo," soil constitutes about one-third of the area of South Dakota west of the Missouri River. The Belle Fourche Field Station is situated on this type of soil, and the results at this station are to be applied to this soil in particular. It is on soil of this type that dry farming is the most difficult and that crop production is the least successful. Both the expense of working the soil and the fact that crops show less drought endurance on this heavy soil than on lighter soils contribute to this result. So far as soil conditions are concerned, the lighter the soil the more certain crop production should be, provided the soil is not so light that soil blowing becomes a factor. The lighter soil will probably not produce as high yields as the heavy soil in favorable years, but will endure more drought and produce better yields in years of partial failure. Average yields obtained at Newell are doubtless lower than would be obtained in more favorable soils in western South Dakota.

The station at Ardmore is located in a soil of heavy clay type, but deeper and somewhat lighter than the "gumbo" of the station near Newell.

CLIMATE

The average annual precipitation in western South Dakota, exclusive of the area influenced by the Black Hills, varies from 13 to 18 inches. At both Newell and Ardmore about two-thirds of the total precipitation occurs during the five months from April to August, inclusive. The precipitation during the growing season, like the annual precipitation, is variable in both quantity and distribution. Both of these factors are of great importance in determining crop production. Low seasonal rainfall is usually accompanied by high evaporation and possibly by unfavorable temperatures and hot winds. The same may be true of a seasonable precipitation normal in quantity but not well distributed. A well-distributed seasonal rainfall of average or more than average amount is usually accompanied by favorable growing conditions.

Only in exceptional years is the precipitation high enough and sufficiently well distributed to allow all crops to mature without their growth being checked to some extent by drought. Likewise it is rare for any year to be so dry that complete failure of all crops occurs.

In most years there is drought injury, varying in extent with the amount and distribution of the precipitation and with the intensity of other climatic factors. This injury seldom affects all crops equally. A complete failure of small grains, which make their growth early in the season, may occur in a year when good yields of late-growing cultivated crops are obtained, or a good yield of small grain may be obtained in a year when cultivated crops do not do well.

The distribution of rain through the growing season is usually the deciding factor in determining which crops will be successful in any given year. The fact that one crop may do well in a year when another crop fails tends to make some diversification of crops necessary, in order that complete failure may be avoided as far as possible.

The amount and the distribution of the precipitation are well shown in Table 1, compiled from the records of the Belle Fourche Field Station. The precipitation at Ardmore is about the same, the average for the 14-year period from 1912 to 1925, inclusive, being 16.43 inches, or only 0.19 inch less than the average at Newell for the same years.

TABLE 1.—*Precipitation at the Belle Fourche Field Station, Newell, S. Dak., for the 18-year period from 1908 to 1925, inclusive*

[Data in inches; T.=trace]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1908	0.20	0.19	1.65	1.16	3.96	1.47	1.26	0.62	0.52	2.08	0.20	0.91	14.16
1909	.17	.23	.19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	17.78
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.08	2.92	.27	.11	.10	12.55
1911	.13	.06	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	12.53
1914	T.	1.00	.29	1.09	2.22	2.09	1.34	1.12	.35	1.77	0	.43	11.70
1915	.92	1.01	.16	2.58	2.32	4.74	5.74	.44	1.26	1.25	.48	.17	21.02
1916	.36	.23	.98	.64	3.17	2.19	2.01	2.02	.20	.99	.33	.28	13.40
1917	.92	.74	.27	2.51	3.71	.97	.80	1.67	.35	.46	T.	.92	13.32
1918	.99	.64	.81	2.40	1.60	1.17	3.41	2.99	3.08	.22	.15	.85	18.31
1919	.04	.57	.87	2.14	1.14	.35	2.59	1.02	1.20	2.49	1.22	.62	14.25
1920	.65	.16	1.35	2.59	8.35	5.90	2.53	.56	.68	1.67	.55	.96	25.80
1921	.29	T.	.84	.72	1.44	3.36	2.30	.52	.72	.10	.30	.50	11.09
1922	1.31	.38	.20	2.84	3.42	3.74	6.52	.90	T.	.79	2.82	.24	23.16
1923	.22	.23	.32	.82	2.31	3.81	4.54	5.35	5.96	3.14	.27	.41	27.37
1924	.06	.88	.70	.81	.68	1.27	1.22	2.00	.72	3.86	.98	.65	13.80
1925	.33	.21	.18	1.53	1.55	3.10	.39	.76	.65	.96	.19	.91	10.76
Average	.45	.42	.64	1.50	2.54	2.51	2.38	1.47	1.47	1.31	.52	.56	15.77

CROP PRODUCTION

Water stored in the soil at seeding time is used by the crops, and to the extent to which it is needed and is able to supplement the rainfall may determine the yield, but in this region it is not sufficient in itself to produce crops. Production is dependent upon the rainfall of the season in which the crops are growing. It is consequently impossible to tell from the character of the winter or from the amount of precipitation before seeding what the chances of success with the different crops may be.

Thus, the choice of crops, aside from winter wheat, in any given year should not be influenced to any great extent by conditions before seeding. The best farm practice is to select the crops that have shown the best average results for a number of years and devote a certain area of land to these each year rather than to try to base the acreage to be devoted to crops and the kind of crops to be grown upon conditions prevailing before seeding in any year.

Successful crop production in western South Dakota must embody the following: (1) The selection of crops best adapted to the locality and the best varieties of these crops, (2) the use of cultural methods that will give the greatest return for labor in the production of these adapted crops, and (3) the adoption of a system of farming in which crop production supplements the other lines of farm activities.

ADAPTED CROPS

The crops adapted to western South Dakota consist principally of small grains, cultivated crops, and pasture and hay crops. These will be considered separately.

SMALL GRAINS

The production of small grains at both the Belle Fourche and the Ardmore Field Stations has been uncertain in the extreme, though in the average of a series of years most grain crops have shown profitable yields. Analysis of the results shows that the fairly good average yield is the result of high yields in good years and low yields in other years rather than of fairly good yields each year. The average yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche Field Station and at the Ardmore Field Station are shown in Table 2. The yields given are the averages of all methods under trial and represent an approximately equal number of the better and poorer yielding methods. They are probably above the averages obtained by all farmers, but it ought to be possible for farmers using only the best methods to equal or exceed them.

TABLE 2.—*Yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche and Ardmore (S. Dak.) Field Stations for certain years in the 17-year period from 1909 to 1925, inclusive*

Station and year	Winter wheat	Spring wheat	Oats	Barley	Corn		Sorgo, total
					Grain	Stover	
Belle Fourche:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Pounds*	*Pounds*
1909	28.9	28.7	60.9	31.7	19.3	3,306	5,920
1910	1.8	2.6	6.8	3.0	.6	2,839	3,360
1911	0	0	0	0	0	0	0
1912	0	0	8.2	.7	21.9	2,623	4,100
1913	21.3	10.8	23.9	10.1	8.6	986	3,400
1914	18.2	10.1	26.3	9.5	.5	1,115	1,725
1915	36.2	57.6	125.6	72.2	44.5	2,785	6,450
1916	12.7	17.3	33.3	31.0	32.5	2,198	9,650
1917	3.8	7.4	17.1	22.9	20.4	1,969	3,300
1918	27.1	11.9	23.3	14.6	30.0	2,977	7,700
1919	2.0	.9	2.3	1.3	.3	235	0
1920	1.6	29.9	63.8	60.9	37.4	2,008	5,900
1921	5.4	7.3	11.6	12.8	9.0	1,435	2,450
1922	30.8	32.2	66.0	44.8	42.3	3,069	5,950
1923	21.3	28.0	57.5	47.9	52.4	3,379	7,820
1924	30.5	21.5	44.1	28.3	17.7	1,122	3,540
1925	23.6	19.8	52.2	32.3	9.0	1,710	4,640
Average	15.6	16.8	36.6	24.9	20.4	1,986	4,465
Ardmore:							
1913	1.4	2.0	2.3	1.4	0	927	
1914	0	0	0	0	0	1,018	
1915	33.2	46.8	77.2	52.9	38.8	3,669	
1916	31.3	21.1	39.8	23.4	22.1	3,026	6,240
1917	7.2	9.2	15.2	5.3	13.9	1,410	3,100
1918	19.4	35.0	65.1	39.9	22.2	2,110	6,700
1919	18.3	11.6	22.4	8.6	9.2	1,524	3,964
1920	25.7	28.1	56.8	35.1	19.3	1,660	4,040
1921	16.0	18.6	42.5	14.4	7.9	1,976	4,290
1922	0	0	0	0	14.8	1,386	4,309
1923	17.4	24.4	59.1	43.5	29.5	2,607	7,180
1924	9.3	11.9	13.3	11.2	2.4	1,978	2,090
1925	[1] 10.2	17.1	33.6	32.3	13.0	2,013	3,940
Average	14.6	17.4	32.9	20.6	14.9	1,946	4,584

[1] Yield from reseeding to spring wheat.

The yearly results in Table 2 show why grain farming in this section has not been successful. The average yield of spring wheat at the Belle Fourche Field Station has been 16.8 and at Ardmore 17.4 bushels per acre. If it were possible to obtain these yields of wheat each year, wheat raising could be made a profitable type of farming. However, in 9 of the 17 years at Belle Fourche and in 6 of the 13 years at Ardmore the yield of wheat has been considerably below these averages, and in these years wheat has been grown either at a loss or at a very small profit. As many as three years of nearly complete failure have occurred successively. This explains why wheat production has been an unstable type of farming.

Wheat raising alone is not successfully maintained where in so large a proportion of the years it must be carried on at a loss or at a very small profit. It can, however, be carried on profitably in connection with livestock production, provided it can be handled in such a way as to require a minimum of labor and expense.

The same is true of oats and barley. Their yields have been relatively about the same as that of spring wheat, and the drought resistance of the three has been practically the same. Choice between these three crops must depend primarily upon individual conditions that determine which crop can be most profitably disposed of.

Winter wheat survives the winter in only a small portion of western South Dakota. When it endures, it may produce a higher yield and be more profitable than spring wheat. When it winterkills, the land can be reseeded to spring wheat or some other crop without any further expense than seed and seeding. When there is not sufficient moisture in the soil in the fall to insure germination of the seed, the planting of winter grains is not advisable.

Winter rye has not been so profitable as winter wheat in the section where winter wheat does well. It is, however, more hardy and will endure the winter in any section of the State. Over most of western South Dakota it is generally as profitable as the spring grains. It ripens earlier in the season and consequently often escapes periods of drought that affect spring-seeded crops. For this reason it is a more dependable crop than the spring grains, though its yield does not compare favorably with theirs in years of high production.

The yields of flax at these stations have not been high. Flax has been generally grown as a sod crop on new breaking, and in this connection has given poor yields. Flax on old ground or upon land broken the previous summer has given better results, but even then has not been so good as other grain crops. It is particularly adapted for growth where a cash crop is desirable and where a long haul to market is necessary. Its high price in proportion to its bulk makes it a valuable crop in this connection, even though the weight of the product per acre is relatively smaller than that of other grains.

The best varieties of these different grain crops and the best time and rate of seeding recommended as a result of extensive tests conducted by the Office of Cereal Crops and Diseases, Bureau of Plant Industry, are stated in Farmers' Bulletin 878, "Grains for Western North and South Dakota,"[1] as follows:

Varieties.—Winter wheat (in the vicinity of the Black Hills), Kharkof, Turkey; spring wheat, Kubanka, Marquis; oats, Kherson, Sixty-Day; barley,

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[1] By F. Ray Babcock, John H. Martin, and Ralph W. Smith.

White Smyrna, Hannchen; rye, North Dakota No. 959, Swedish; flax, North Dakota No. 155, Damont.

Time of seeding.—Sow spring wheat and oats as early as the land can be put in good condition, barley after wheat and oat seeding is finished, and flax about May 1. Sow winter wheat and winter rye in late August or early September in North Dakota and in September or early October in South Dakota.

Rate of seeding.—The best rates of seeding are as follows: Spring wheat, 4 pecks per acre; winter wheat, 3 to 4 pecks per acre; oats and barley, 5 to 6 pecks per acre; flax, 20 to 30 pounds per acre.

CULTIVATED CROPS

Corn is the cultivated crop grown most generally in western South Dakota. There are varieties that will ripen in all parts of this section. A yield of grain can not be obtained every year, but a yield of fodder is fairly certain. Sorgo is the only other crop that offers possibilities of competing with corn as a coarse feed crop in this section. Table 2 presents the average annual yields of both corn and sorgo at both the Belle Fourche and the Ardmore Field Stations. This table shows that at each station corn has produced a good crop of grain in about half the years. At Ardmore there has been some crop, at least of stover, every year, but at Belle Fourche there was complete failure in 1911 and a failure from most methods in 1919. In both years the ground was so dry at corn-planting time that the seed did not germinate. Sorgo failed in those years at Belle Fourche for the same reason.

The greatest value of corn as a dry-land crop is its ability to produce a fair yield of stover even in dry years. Corn fits in admirably with the raising of livestock and can be depended upon to produce winter feed for them in most years so dry that the growth of grass on the prairie is scant and opportunities for cutting hay are limited. In addition to this, corn in more favorable years produces a fairly good yield of grain. The combined value of the grain and stover tends to make corn the most profitable dry-land crop in this area. As the number of stock in the section increases and the area of land where hay can be cut becomes smaller, farmers will be more and more dependent for their winter feed upon crops like corn that produce a large yield of rough feed per acre.

Sorgo produces a higher yield of stover per acre than corn over most of western South Dakota, and the stover is more palatable. It does not appear likely, however, to replace corn to any considerable extent in this section. The combined value of the grain and stover of corn is greater than the stover value of sorgo. This, together with the fact that corn is easier to produce, makes it seem certain that corn will continue to be the leading cultivated crop. It is worthy of note, however, that in a considerable number of years at both the Belle Fourche and Ardmore stations when the yield of ear corn was low, the yield of sorgo was proportionately greater than in more favorable years. A portion of the corn acreage could well be replaced by sorgo as an insurance against failure of the feed crop in unfavorable years.

The varieties of corn best suited to western South Dakota vary with the locality. Near the northern part of the State, only very early corn will mature. In the central and southern portion the earlier dent corns, such as Northwestern and Payne White, have been most successful. In many places some unnamed varieties have been grown in restricted localities for a number of years. In most cases adapted acclimated varieties like these are as valuable as the standard varieties that are more widely known.

Only the sweet sorgos are adapted for growth as far north as South Dakota. Minnesota Amber, Dakota Amber, and Red Amber are the most promising varieties.

PASTURE AND HAY CROPS

At least in the " gumbo " soils of western South Dakota the growth of pasture crops has not been and is not likely to be practiced. The expense of preparing the ground and seeding a pasture crop, together with the fact that a comparatively large acreage is required for each animal pastured, makes the initial cost almost prohibitive.

Alfalfa and brome grass offer possibilities as hay crops. The yield of feed is much less per acre than that of corn and similar crops, but there is an advantage in that they do not need to be planted each year. Alfalfa at least will endure for an indefinite number of years. It will produce a cutting practically every year, though the growth may be checked by drought before the alfalfa comes into bloom. Three cuttings have been produced at the Belle Fourche Field Station in only one year and two cuttings in three other years. In one year, 1911, the crop was a total failure. At the Ardmore Field Station it has failed twice and produced two crops twice.

Alfalfa is particularly adapted for growth along streams or on bottom lands where the ground water is within reach of the roots. Under conditions like this it will make two or three cuttings each year. Brome grass is particularly adapted to places that receive considerable run-off. In such situations it can be depended upon to produce one good-sized crop of hay each year until it becomes sod bound. The greater feeding value of alfalfa and the fact that it produces nearly as much hay as brome grass and does not become sod bound make it much more valuable as a hay crop.

In addition to its value as a forage crop, alfalfa is often of great value as a seed crop. In years when seed production is good, the value of the seed is usually far greater than that of the forage. When a seed crop is obtained, the straw from which the seed has been separated is readily eaten by stock and has a greater nutritive value than grain straw.

The ability of alfalfa to produce seed depends to a great extent upon the type of soil upon which it is grown. On the heavy clay soils, like that at Belle Fourche, alfalfa seldom produces seed after it has once been established, even when grown in cultivated rows. The plant generally begins to suffer from drought before it comes into full bloom, and little seed is formed.

On lighter soils alfalfa suffers less severely from drought and produces seed in most years if it is grown in cultivated rows or broadcast with a very thin stand. Culture in rows is the surest method of producing seed, but the expense of cultivation reduces the profit from this method to some extent. Practically the same forage yield is secured from alfalfa in cultivated rows and that sown broadcast.

On soils where ground water is within reach of the roots a seed crop is obtained nearly every year. Where this condition exists no advantage is to be gained by growing in cultivated rows. Either the first or the second cutting may be left for seed. When the second cutting is left for seed, a cutting of hay is obtained in addition to the seed crop.

With the exception of land where the ground water can be reached by the roots, alfalfa seed production is not sufficiently certain to become a part of any definite farming system. However, on the lighter soils of western South Dakota a certain part of the land can be planted to alfalfa to very good advantage. In years of good seed production the alfalfa can be saved for seed. In years when it seems apparent that little seed will be formed, the crop can be cut for hay. Used in this way, it will be valuable in all years except those of complete failure.

The variegated alfalfas—Grimm, Baltic, and Cossack—have shown slightly better yields and greater hardiness than common alfalfa.

CULTURAL METHODS

The cultural methods that have been under trial consist of spring plowing, fall plowing, disking, listing, subsoiling, summer tillage, and the plowing under of green-manure crops.

The number of tillage operations required for preparing the land for a crop varies a great deal with these different cultural methods. The time at which the labor must be performed likewise varies. The tillage operations involved in each method of cultivation and the time at which they may be best performed are as follows:

Spring plowing for all small grains should be done as early as weather conditions will permit. Plowing to a depth of 4 to 6 inches is advisable. The land should be disked before it has a chance to dry out and harrowed at least once after plowing. Spring plowing for corn may be delayed until after small grains are seeded.

Fall plowing may be done at any time after harvest. From 5 to 8 inches constitutes a good depth. As the land is usually dry in the fall, it is best to leave it rough until spring. A double disking and a harrowing in the spring are all the preparation necessary before seeding small grains. Where a later seeded crop is to be planted, additional cultivation may be required in order to keep the land free from weeds until seeding. Fall plowing offers a better distribution of labor than spring plowing.

Disking without plowing at the Belle Fourche and Ardmore stations has been practiced only for small grains and only on land where an intertilled crop has been grown. Double disking and harrowing in the spring are all the preparation required before seeding.

Listing for small grains may be done at any time after harvest. The lister should be run a little deeper than for planting corn, and the furrows should be about the same distance apart as for corn. The land may be left rough over winter and worked down level in the spring. Normally, two diskings and a harrowing are required. Listing for corn is usually done with a lister planter. No cultivation before planting is required where corn is planted in this manner.

Subsoiling is done at the same time as fall plowing. The land is plowed with an ordinary plow to a depth of 8 inches, and a subsoil plow is run in alternate furrows to an additional depth of 8 inches, making a total depth of 16 inches. As the time and labor necessary for plowing with the subsoil plow are at least as great as for original plowing, the cost of the whole operation is practically that of two plowings. The spring cultivation needed for subsoiled land is the same as for land given an ordinary fall plowing.

Land to be summer-fallowed should be plowed about 8 inches in the spring or early summer, worked down immediately after plowing, and kept free from weeds during the rest of the season. This usually requires at least two diskings and several harrowings. The disk and harrow, however, may well be replaced by sweep or shovel cultivators of the duck-foot type. Recent experiments have even shown the possibility of omitting the plowing when such cultivators are used. They are efficient in preventing weed growth and leave the surface granular and ridged. This condition facilitates the penetration of water and protects against soil blowing. Fallowing requires the use of the land two years for the production of one crop and, consequently, is an expensive method.

Green manuring is the most expensive method that has been tried. It involves the preparation of land for the green-manure crop, the cost of seed and seeding, the plowing under of the green-manure crop, and the keeping of the land free from weeds the rest of the season. Usually two plowings, at least two diskings, and two or more harrowings are required. The loss of the land for a year is also an item of expense in preparing land by this method.

The different crops vary in their response to these cultural methods. For this reason grain crops, cultivated crops, and hay crops are considered separately.

SMALL GRAINS

The results at the Belle Fourche Field Station indicate clearly that the most profitable crops of grain are produced by the cheaper methods of soil preparation. Grain on disked corn land or on disked land where some other cultivated crop has been grown has shown the highest net profit of any method of soil preparation tried. This is due largely to the low cost of production, but partly to the fact that disked cultivated land has generally produced yields above the average. The yields of wheat, oats, and barley on disked corn land have been higher than the yield of the same crops on spring or fall plowed corn land. In other words, plowing corn land either in the spring or in the fall has been accompanied by an actual loss in yield, as well as by the increased cost of production due to the plowing. It must be borne in mind that the corn ground had been kept free from weeds. If weeds had been allowed to grow, the results probably would not have been so favorable. With the corn ground kept clean, the production of grain on the disked corn land is by far the most profitable method of production that has been tested.

Spring and fall plowing are about equal as methods of land preparation for grain. Practically the same amount of labor is necessary for the preparation of a seed bed, and when seeding is done at the same time the yields produced are nearly the same. Fall plowing can be done at a time when work is not so pressing, consequently it has an advantage over spring plowing in that respect. As seeding can be started as early as plowing, fall-plowed land can be seeded earlier than land that must be plowed in the spring. This consideration becomes most important in seasons when unfavorable weather conditions hinder spring work. This is a decided advantage for fall plowing, because early-seeded crops mature earlier and as a result often escape periods of drought that injure later seeded crops. However, if the conditions in the fall are such that plowing can not be done, a farmer may do his plowing in the early spring and be assured of practically the same returns as when land has been plowed in the fall, provided seeding is not unduly delayed.

Plowing is more expensive than disking in preparing land for grains. When small grains follow corn, better yields are obtained by disking. Plowing grain stubble is recommended for use only in the sections of western South Dakota where grain growing is most successful and where the desired grain acreage is greater than the area devoted to corn. Over the area represented by the station near Newell the yields are so low that the production of grain, other than on disked corn land, is more likely to result in loss than in profit.

The yields of grain on listed land compare favorably with those on plowed land. The cost of production on listed land is slightly lower, so the net return is a little higher. The difference in return, however, is not great enough to justify the purchase of any special equipment for growing grains on listed land.

The more intensive methods of cultivation, such as fallowing and plowing under green-manure crops, have not proved profitable in grain production. The yield of grain has been increased both by fallowing and by the plowing under of green-manure crops. In but few cases has the increase been large enough to pay for the added expense. In years of high rainfall other methods are as good; in years of low rainfall all methods fail; only in some years of partial failure do these methods show to advantage. On an average, their use over the period covered by the experiments has resulted in a smaller profit for fallowing than for cropping each year and a net loss for plowing under green-manure crops.

Subsoiling and deep tillage have neither increased nor decreased yields to a measurable extent. They have simply added to the cost of producing grains without adding to the value of the crops produced. Consequently these practices have been less successful than cheaper methods of cultivation.

Intensive tillage methods can not be expected to pay in a section where the net profits per acre are low and where yields are not greatly increased by their use. The same amount of labor distributed over more acres would be a more profitable investment.

Subsoiling, green manuring, and fallowing are not recommended as general practices for any section of western South Dakota.

CULTIVATED CROPS

Spring and fall plowing have given about equal results as methods of soil preparation for corn. Fall plowing requires a little more cultivation in that a certain amount of spring cultivation is necessary in order to keep the land clean until the corn is planted. It has a slight advantage in that the corn usually comes up a little sooner and matures just a little earlier. There is no great difference in yields, and the farmer may arrange to do his plowing at any time previous to planting without materially affecting the yield.

Listing for corn has given lower yields than spring or fall plowing. The low cost of land preparation, however, makes the net profit per acre fully as high. In spite of this, listing is not likely to meet with favor in western South Dakota. Corn on listed land has a tendency to come up a little more slowly and to mature a little later than corn on plowed land. There is also some difficulty in obtaining a stand.

The more intensive methods of tillage have shown less response with corn than with small grains.

Fall plowing has been superior to spring plowing as a method of land preparation for sorgo. The difference has been largely due to stand. Spring-plowed land of the heavy clay type can not always be worked down to form a good seed bed for sorgo, because of its tendency to remain lumpy until mellowed by rains. In seasons that are dry between plowing and planting time, the fine seed bed necessary to give a good stand of sorgo can not be obtained.

HAY CROPS

Hay crops, such as alfalfa and brome grass, are not adapted for use in rotations. They should be seeded in spring or early summer on land fall plowed, worked down to form a solid seed bed in spring, and kept free from weeds until seeding. After a stand of these crops has been obtained they should not be plowed up, but should remain intact as a hayfield so long as the production remains good. Brome grass may be pastured to good advantage for several years after it becomes so sod bound that it no longer produces a profitable yield of hay. Crops following alfalfa and brome grass are usually poor, on account of the extremely dry condition in which the soil is left.

THE BEST SYSTEM OF FARMING

The system of farming that offers the greatest possibility of a permament agriculture for western South Dakota is one in which crop production is combined with the raising of livestock. Crop production alone can not be depended upon for a successful type of farming, as the cash crops, such as small grains, are subject to failure and the margin of profit is low. The more certain crops, such as corn stover and sorgo, can not be grown with profit unless fed near where they are produced. Their bulky nature prevents long hauls, and their sale price is far below their feeding value. The production of livestock alone is likewise subject to limitations. The most prominent of these is the question of winter feed. In dry years the growth of grass on the Great Plains is scant, and the quantity of hay that can be cut is limited. Unfortunately the livestock need the most land for pasture in the particular seasons when the acreage that must be cut for hay must be extended if an adequate supply of winter feed is to be obtained. The best way to meet this condition is to grow some annual crop, such as corn, that produces a comparatively large bulk of rough feed per acre.

The system of farming that suggests itself is as follows: (1) The production of livestock up to the limit of pasture in dry years, (2) the planting of an acreage of corn sufficient to meet the winter demands of the stock to be carried over, and (3) the production of small grain on the corn land.

The limit of livestock production for any one farmer lies primarily in the area of pasture land he has after an acreage sufficient for growing crops has been set aside. The number of livestock that should be kept should be limited by the extent of pasture available in a dry year rather than by that of a favorable season. It is better to undergraze land in good seasons than to overgraze it in years of drought. The carrying capacity of different sections varies with the native vegetation. What the carrying capacity of any particular section is must be determined by observation and experience.

Corn stover offers a solution of the question of winter feed. As has been shown in considering corn and sorgo, they can be practically relied on to furnish the rough feed each year. Ear corn is produced in paying quantities in more than half the years, and when obtained it can be well utilized either for feed or for sale. Since corn does well on either spring or fall plowing, the work preparatory to planting can be done at the time when it interferes least with other farm work. The acreage of corn and sorgo grown should be sufficient to insure winter feed for the livestock to be carried over. The acreage should be fixed by the quantity necessary for winter feed in years when the production of stover is not high. In years of extraheavy production the excess feed can be carried over or the number of stock increased for winter feeding.

Although corn and livestock must form the basis of a permanent agriculture in this section, grains can be grown in connection with them as a speculative crop, with the chances of profit very good and the chance of total failure low. The corn ground provides one of the best preparations for small grains, on which they can be grown at a very low cost. Their yield, consequently, does not need to be heavy in order to be profitable. In years of high production they are very profitable. The land planted to corn in one year may be planted to small grain the next without expense other than disking, harrowing, seed, and seeding. In years when the conditions favor grain production, the value of the grain crop far exceeds the cost of production. In years when it seems apparent that no grain will be produced, the small-grain crops may be cut for hay and a supplemental supply of winter feed thus procured. This will make the grain crops of value in seasons when their production for grain is a failure. As has been stated, the corn should be kept clean. The cost of keeping the corn free from weeds is more than made up in the added value of the following crop. The kind of small grain to be raised must depend upon the needs of the individual farmer.

With modifications, this system of farming should be adapted to any part of western South Dakota. In places where grain does well, the acreage of small grains may exceed the corn acreage. The extra acreage of small grain will then be grown on either spring or fall plowing following small grain. On farms where particular land conditions, such as land along streams, favors the growth of alfalfa and brome grass, the acreage of corn grown may be reduced. With modifications to meet special conditions, such a combination of crop growing with livestock production holds promise of forming the basis of a stable system of farming for western South Dakota.

The climatic records available cover a much longer period than those of crop production. They show that such extreme years as 1911 are very infrequent. Such years, as well as less extreme ones like 1919, may be provided against in part by a liberal carry over of surplus feed from years of heavy production. They must be met in part by the importation of feed and in part by the temporary reduction of herds and flocks. The essential thing is that farms be so capitalized that they can stand the strain of such reverses and continue as going concerns prepared to obtain the returns of the good and the average years.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

October 25, 1926

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1163

DRY FARMING IN WESTERN SOUTH DAKOTA

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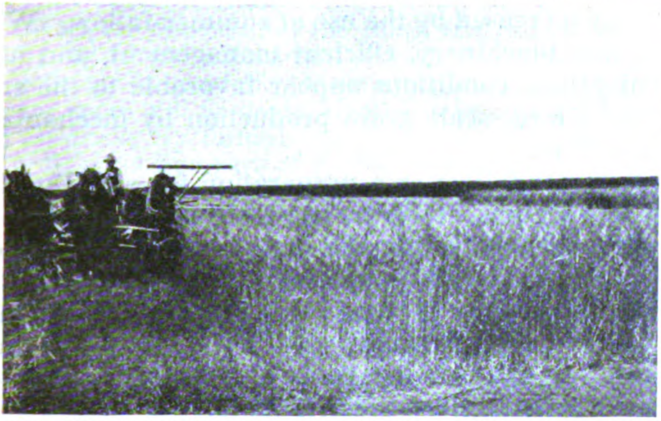

GRAIN CROPS in western South Dakota, in the average results of a series of years, show yields that should be profitable, but the averages are made up of heavy yields in some years and low yields or failures in other years rather than fairly good yields each year. This indicates an unstable condition of grain farming.

The investigations of the United States Department of Agriculture at the Belle Fourche Field Station, near Newell, since 1908, and at the United States Dry Land Field Station, Ardmore, since 1912, show that the sureness of grain production can be considerably increased by the use of summer-fallow. With modern machinery, efficient management, and normal prices, conditions appear favorable to the success of large-scale grain production by mechanized agriculture.

Summer-fallow as a preparation for small grains in this section, however, has a strong competitor in cultivated feed crops, the most important of which is corn. Livestock is necessary to the utilization of such crops. For the majority of farmers a combination of crop growing with livestock production promises to form the basis of a stable system of farming for western South Dakota.

Washington, D.C. Issued September 1920; revised August 1933

DRY FARMING IN WESTERN SOUTH DAKOTA

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AGRICULTURAL CONDITIONS

WESTERN SOUTH DAKOTA is largely a dry-farming country. With the exception of the Black Hills and a narrow belt of land adjacent to and influenced by them, it lies within a region normally deficient in rainfall. A certain part of this territory is irrigated, and more will no doubt eventually be reclaimed, but most of it must always be dry farmed.

Attempts to make this part of South Dakota a strictly crop-producing section have been unsuccessful. Settlement in this country generally was made after a series of good years had created an exaggerated idea of its crop possibilities. Only those settlers who turned to the raising of livestock as their principal industry were able to remain.

Developments in farm equipment during the last decade have made it possible for one man to handle a large acreage of ground, and have made crop production relatively more important than it was a few years ago. In spite of this fact, crop production alone offers a possibility of success only under the most efficient type of management. The production of livestock remains the basic industry of the section. The best development of the livestock industry requires the growth of a certain proportion of crops. This bulletin, in reporting the results of studies of methods of crop production, indicates a way in which the two enterprises may be combined and each made more successful. In addition, it indicates a way in which crop production alone may be made more stable. The recommendations are based upon results obtained on the dry-farming unit of the Belle Fourche Field Station, near Newell, S.Dak., established in 1908, and on those of the United States Dry Land Field Station at Ardmore, established in 1912. At both stations all the adapted crops have been under trial each year under all the combinations and methods that appear likely to be practiced or to offer a possibility of success.

TOPOGRAPHY

Most of western South Dakota is a Plains section. There are portions too rough for cultivation, but by far the larger part is physically suited to crop raising. Much of it consists of rolling hills whose slopes are generally not too steep to be cultivated. Economic conditions that decide how much of the land can be profitably cultivated, rather than the topography of the country, will determine the area of land devoted to crops.

SOILS

The soils of western South Dakota range from almost pure sand to a very heavy clay, or gumbo. The Pierre clay, or gumbo, soil constitutes about one third of the area of South Dakota west of the Missouri River. The station near Newell is situated on this type of soil, and the results at this station apply particularly to it. On soil of this type dry farming is most difficult and crop production least successful. Both the expense of working the soil and the fact that crops show less drought endurance on this heavy soil than on lighter soils contribute to this result. So far as soil conditions are concerned, the lighter the soil the more certain crop production should be, provided the soil is not so light that it blows. The lighter soil probably will not produce yields as high as those on the heavy soil in favorable years, but will endure more drought and produce better yields in years of partial failure. Average yields obtained at Newell are doubtless lower than would be obtained on more favorable soils in western South Dakota.

The station at Ardmore is located in a soil of heavy clay type, but deeper and somewhat lighter than the gumbo of the station near Newell.

CLIMATE

The average annual precipitation in western South Dakota, exclusive of the area influenced by the Black Hills, ranges from 13 to 18 inches. At both Newell and Ardmore about two thirds of the total precipitation, which averages about 16⅓ inches at each place, occurs during the 5 months from April to August, inclusive.

Only in exceptional years is the precipitation high enough and sufficiently well distributed to allow all crops to mature without having their growth checked to some extent by drought. Likewise it is rare for any year to be so dry that all crops fail completely.

In most years there is drought injury, varying in extent with the amount and distribution of the precipitation and with the intensity of other climatic factors. This injury seldom affects all crops equally. Small grains, which make their growth early in the season, may completely fail in a year when late-growing cultivated crops make good yields, or a good yield of small grain may be obtained in a year when cultivated crops do not produce well.

The distribution of rain through the growing season is usually the deciding factor in determining which crops will be successful in any given year. Because one crop may do well in a year when another crop fails, some diversification of crops is desirable.

CROP PRODUCTION

Water stored in the soil at seeding time is used by the crops, and, so far as it is needed and is able to supplement the rainfall, may determine the yield. In this region, however, such moisture alone is not sufficient to produce crops. Production depends upon the rainfall during the season in which the crops are growing.

Therefore, except for winter wheat, the choice of crops in any given year should not be influenced to any great extent by conditions before seeding. The best practice is to select crops that have shown the best average results for a number of years and to devote a certain area of land to these each year, rather than to try to base the acreage to be devoted to crops and the kind of crops to be grown upon conditions prevailing before seeding time in any particular year.

Successful crop production in western South Dakota must embody the following principles: (1) The selection of crops best adapted to the locality and the best varieties of these crops, (2) the use of cultural methods that will give the greatest return for labor in the production of these adapted crops.

ADAPTED CROPS

The crops adapted to western South Dakota are principally small grains, cultivated crops, and pasture and hay crops.

SMALL GRAINS

Production of small grains at both stations has been uncertain in the extreme, though in the average of a series of years most grain crops have shown satisfactory yields. The fairly good average yields represent high yields in good years and low yields in other years, rather than fairly good yields each year.

The longest period during which good yields were obtained each year was at the Belle Fourche Field Station during the years from 1922 to 1930, inclusive. The most extended period of nearly complete failures due to drought was at the same station during the years 1910, 1911, and 1912.

The average yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the two stations are shown in table 1. The yields given in this table are the averages of all methods under trial, and for most crops they represent an approximately equal number of the better and the poorer yielding methods. They are probably above the averages obtained by all farmers, but it should be possible for farmers using only the best methods to equal or exceed them.

The yearly results in table 1 show why grain farming alone has resulted in so many failures in this section. If it were possible to produce each year a yield of wheat nearly equal to the average, without doubt wheat raising would have been a profitable type of farming. The fact that yields may be very high or very low has made wheat production very unstable. In the past, several successive years of failure or near failure in the wheat crop usually resulted in impoverishing the farmers depending upon wheat alone to such an extent that they were forced to leave the land or to reduce their operations so much that they were unable to profit during the succeeding good years. Farmers whose livestock provided some income during poor crop years were able to continue.

TABLE 1.—*Yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche Field Station, Newell, S.Dak., and the United States Dry Land Field Station, Ardmore, S.Dak., for certain years in the 22-year period from 1909 to 1930*

Station and year	Winter wheat	Spring wheat	Oats	Barley	Corn		Sorgo, total
					Grain	Stover	
Newell:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Pounds*	*Pounds*
1909	28.9	28.7	60.9	31.7	19.3	3,305	5,920
1910	1.8	2.6	6.8	3.0	.6	2,839	2,360
1911	0	0	0	0	0	0	0
1912	0	0	8.2	.7	21.9	2,623	4,100
1913	21.3	10.8	23.9	10.1	8.6	986	3,400
1914	18.2	10.1	26.3	9.5	.5	1,115	1,725
1915	36.2	57.6	125.6	72.2	44.5	2,785	6,450
1916	12.7	17.3	33.3	31.0	32.5	2,198	9,650
1917	3.8	7.4	17.1	22.9	20.4	1,969	3,300
1918	27.1	11.9	23.3	14.6	30.0	2,977	7,700
1919	2.0	.9	2.3	1.3	.3	235	0
1920	1.6	29.9	63.8	60.9	37.4	2,008	5,900
1921	5.4	7.3	11.6	12.8	9.0	1,435	2,450
1922	30.8	32.2	66.0	44.8	42.3	3,069	5,950
1923	21.3	28.0	57.5	47.9	52.4	3,379	7,820
1924	30.5	21.5	44.1	28.3	17.7	1,122	3,540
1925	23.6	19.8	52.2	32.3	9.0	1,710	4,640
1926	32.4	31.3	59.7	44.1	33.4	1,852	6,530
1927	11.4	21.6	39.1	13.2	30.3	2,786	7,260
1928	25.8	32.9	66.0	49.3	32.3	1,445	4,690
1929	33.6	28.3	57.0	36.3	28.4	1,624	5,020
1930	19.9	15.4	40.9	32.2	8.4	2,084	5,500
Average	17.7	18.9	40.3	27.2	21.8	1,979	4,768
Ardmore:							
1913	1.4	2.0	2.3	1.4	0	927	----------
1914	0	0	0	0	0	1,013	----------
1915	33.2	46.8	77.2	52.9	38.8	3,669	----------
1916	31.3	21.1	39.8	23.4	22.1	3,025	6,240
1917	7.2	9.2	15.2	5.3	13.9	1,410	3,100
1918	19.4	35.0	65.1	39.9	22.2	2,110	6,700
1919	18.3	11.6	22.4	8.6	9.2	1,524	3,964
1920	25.7	28.1	56.8	35.1	19.3	1,660	4,040
1921	16.0	18.6	42.5	14.4	7.9	1,976	4,290
1922	0	0	0	0	14.8	1,386	4,300
1923	17.4	24.4	59.1	43.5	29.5	2,607	7,180
1924	9.3	11.9	13.3	11.2	2.4	1,978	2,090
1925	[1] 10.2	17.1	33.6	32.3	13.0	2,013	3,940
1926	4.4	7.2	24.8	18.6	11.5	1,931	3,900
1927	18.6	32.6	66.8	50.8	36.5	3,442	9,350
1928	20.5	25.5	46.1	27.7	20.4	1,930	3,240
1929	9.4	13.4	25.1	17.9	10.1	2,562	2,560
1930	9.7	10.2	23.1	23.7	3.6	1,105	3,400
Average	14.0	17.5	34.1	22.6	15.3	2,015	4,553

[1] Yield from reseeding to spring wheat.

Wheat raising alone has not been successful in the past, but it can be carried on successfully in connection with livestock production if it is so handled as to require a minimum of labor and expense.

Under exceptionally able management, wheat growing offers a possibility of success on farms where livestock growing is a minor enterprise. Growing wheat under these conditions requires an extensive acreage and management so efficient that expenses are held to a minimum. In this type of farming summer-fallow offers a probability of success, not as a means of increasing the total yields of a given acreage but as a means of equalizing production among different years and reducing the cost of production.

Oats and barley show the same response to cultural treatments as wheat. The yield of oats in pounds per acre is practically the same as that of wheat at Ardmore and about 200 pounds higher at Newell. Barley has been much more productive than either wheat or oats at both stations. This is not shown in the table of average yields, because a much higher percentage of the barley than of either wheat or oats is grown under poor methods of cultivation. The value of barley is further obscured by the fact that during the first years of the experiments a 6-rowed variety of barley was grown that was much less productive than the 2-rowed variety now grown at both stations. Under comparable methods, the 2-rowed variety of barley has produced an average of about 480 pounds per acre more than oats at Ardmore and 310 pounds per acre more than oats at Newell. Barley is much more valuable in terms of feed produced per acre than any other grain crop.

Winter wheat survives the winter in only a small portion of western South Dakota. When it endures, it may produce a higher yield and be more profitable than spring wheat. When it winterkills, the land can be reseeded to spring wheat or some other crop without any other expense than seed and seeding. When there is not sufficient moisture in the soil in the fall to insure germination of the seed, planting winter grains is not advisable.

Winter rye has not been so profitable as winter wheat in the section where winter wheat does well. It is, however, more hardy and will endure the winter in any section of the State. Over most of western South Dakota it is generally as profitable as the spring grains. It ripens earlier in the season and consequently often escapes periods of drought that injure spring-seeded crops. For this reason it is a more dependable crop than the spring grains, though its yield does not compare favorably with theirs in years of high production.

The yields of flax at these stations have not been high. Flax has generally been grown as a sod crop on new breaking, and when so grown has given poor yields. Flax on old ground or upon land broken the previous summer has given better results, but even then has not been so good as other grain crops. It is particularly adapted as a cash crop and where a long haul to market is necessary. Its high price in proportion to its bulk makes it a valuable crop under such conditions, even though its weight per acre is relatively less than that of other grains. The chief value of flax lies in its use as a speculative crop on new land.

The recommended varieties of the different crops are: Winter wheat, Kharkof, Turkey; spring wheat, Kubanka, Ceres, Marquis; oats, Gopher, Brunker, Sixty-Day; barley, White Smyrna, Horn, Odessa; and flax, Linota, Bison.

Sow spring wheat, oats, and barley as early as the land can be put in condition. Barley responds to early seeding as much as wheat or oats do. Sow flax from April 15 to May 1. Sow winter grains during the last half of September or the first part of October.

The best rates of seeding are: Spring wheat, 4 pecks per acre; oats and barley, 5 to 6 pecks per acre; winter wheat, 3 to 4 pecks per acre; and flax, 20 to 30 pounds per acre.

CULTIVATED CROPS

The cultivated crop grown most generally in western South Dakota is corn. There are varieties that will ripen in all parts of this section. A yield of grain cannot be obtained every year, but a yield of fodder is fairly certain. Sorgo is the only other crop likely to compete with corn as a coarse-feed crop in this section. Table 1 shows that corn has produced a good crop of grain in about half the years at each station. At Ardmore there has been some crop, at least of stover, every year, but at Newell there was complete failure in 1911 and failure under most methods in 1919. In both years the ground was so dry at corn-planting time that the seed did not germinate. For the same reason sorgo failed in those years at Newell.

The greatest value of corn as a dry-land crop is in its ability to produce a fair yield of stover even in dry years. Corn fits in admirably with livestock raising and can be depended upon to produce winter feed for stock in most years so dry that the growth of grass on the prairie is scant and little hay can be cut. In addition, corn produces a fairly good yield of grain in more favorable years. The combined value of the grain and stover tends to make it the most profitable dry-land crop in this area. As the number of stock in the section increases and the area in which hay can be cut becomes smaller, farmers will be more and more dependent for their winter feed upon crops like corn that produce a large yield of rough feed per acre.

The adaptation of corn varies with the type of soil. In general, yields have been higher and more certain on lighter soils than on soils of heavy types like those at the two stations.

Sorgo produces a higher yield of stover per acre than corn over most of western South Dakota, and the stover is more palatable. The combined value of the grain and stover of corn is greater than the stover value of sorgo. This, together with the fact that corn is easier to produce, makes it seem certain that corn will continue to be the leading cultivated crop. However, in a considerable number of years when the yield of ear corn was low at both stations, the yield of sorgo was proportionately greater than in more favorable years. A portion of the corn acreage could well be replaced by sorgo as an insurance against failure of the feed crop in unfavorable years. Sorgo fits into a rotation as well as corn and has proved valuable as a winter feed for steers as well as for horses and young stock.

The varieties of corn best suited to western South Dakota differ with the localities. Near the northern part of the State only very early corn will mature. In the central and southern portions the earlier dent corns, such as Northwestern and Payne White, have been most successful. In many places some unnamed varieties have been grown in restricted localities for a number of years. In most cases adapted acclimated varieties like these are as valuable as the standard varieties that are more widely known.

Only the sweet sorghums are adapted for growth as far north as South Dakota. Minnesota Amber, Dakota Amber, and Red Amber are the most promising varieties.

PASTURE AND HAY CROPS

The principal pasture in western South Dakota is the native sod. The cultivated crop most extensively used is alfalfa. This has proved valuable for hog pasture, though under even the best systems of pasturing there may be times in the summer when it produces no feed. Crested wheatgrass and bromegrass have possibilities as early pasture. Both make a very early growth and can be pastured heavily before native grasses are well started. Both cease growth and become hard and woody during the summer. Their greatest value lies in their ability to produce a large amount of early pasture. A small acreage of either could be used to supplement the native pasture. At Ardmore crested wheatgrass has shown a higher carrying capacity than bromegrass.

Alfalfa is the principal cultivated hay crop, though bromegrass and crested wheatgrass offer possibilities. Their yield of feed per acre is much less than that of corn and similar crops, but there is an advantage in that they do not need to be planted each year. Alfalfa at least will endure for an indefinite number of years. It will produce a cutting practically every year, though the growth may often be checked by drought before the alfalfa comes into bloom· In some years two cuttings and occasionally three cuttings will be obtained.

Alfalfa is particularly adapted for growth along streams or on bottom lands where the ground water is within reach of the roots. Under conditions like these it will make two or three cuttings each year. Bromegrass and crested wheatgrass produce one cutting of hay in most years. Even under the best conditions, however, these crops will not exceed alfalfa in average production.

In addition to its value as a forage crop, alfalfa often has great value as a seed crop. In years when seed production is good, the value of the seed is usually far greater than that of the forage.

The ability of alfalfa to produce seed depends to a great extent upon the type of soil upon which it is grown. On the heavy clay soils, like that at Newell, alfalfa seldom produces seed after it has once been established, even when grown in cultivated rows. The plant generally begins to suffer from drought before it comes into full bloom and little seed is formed. On lighter soils alfalfa suffers less severely from drought and produces seed in most years if it is grown in cultivated rows or broadcast with a very thin stand. Culture in rows is the surest method of producing seed, but the expense of cultivation somewhat reduces the profit under this method. Practically the same forage yield is secured from alfalfa in cultivated rows and from that sown broadcast.

Where ground water is within reach of the roots a seed crop is obtained nearly every year, and there is no advantage in growing alfalfa in cultivated rows. Either the first or the second cutting may be left for seed.

Except where the ground water can be reached by the roots, alfalfa-seed production is not sufficiently certain to become a part of any definite farming system. However, on the lighter soils of western South Dakota a certain part of the land can very advantageously be planted to alfalfa. In years of good seed production the alfalfa can be saved for seed. In years when it seems apparent that little seed will be formed, the crop can be cut for hay.

The variegated alfalfas—Grimm, Baltic, and Cossack—have shown slightly better yields and greater hardiness than common alfalfa.

CULTURAL METHODS

The number of tillage operations required in preparing the land for a crop differs a great deal with different cultural methods. The times at which the labor must be performed likewise differ. The tillage operations involved in each method of cultivation and the time at which they may best be performed are:

Spring plowing for all small grain should be done as early as weather conditions will permit. Plowing to a depth of 4 to 6 inches is advisable. The land should be disked before it has a chance to dry out, and harrowed at least once after plowing. Spring plowing for corn may be delayed until after small grains are seeded.

Fall plowing may be done any time after harvest. From 5 to 8 inches is a good depth. As the land is usually dry in the fall, it is best to leave it rough until spring. A double disking and a harrowing in the spring are all the preparation necessary before seeding small grains. Where a later-seeded crop is to be planted, additional cultivation may be required to keep the land free from weeds until seeding. Fall plowing provides a better distribution of labor than spring plowing.

Disking without plowing, at both stations, has been practiced only for small grains. On land where an intertilled crop has been grown, double disking and sometimes harrowing are all the preparation required before seeding.

Listing for small grains may be done any time after harvest. The lister should be run a little deeper than for planting corn, and the furrows should be about the same distance apart as for corn. The land may be left rough over winter and worked down level in the spring. Normally, two diskings and a harrowing are required. Listing for corn is usually done with a lister planter. No cultivation before planting is required if corn is planted in this manner.

Subsoiling is done at the same time as fall plowing. The land is plowed with an ordinary plow to a depth of 8 inches, and a subsoil plow is run in alternate furrows to an additional depth of 8 inches. As the time and labor necessary for plowing with the subsoil plow are at least as great as for original plowing, the cost of the whole operation is practically that of two plowings. The spring cultivation needed for subsoiled land is the same as for land given an ordinary fall plowing.

Land to be summer-fallowed should be plowed about 8 inches deep during the latter part of May. It may be given a light harrowing immediately after plowing, or it may be left rough until weeds commence to grow. It should be cultivated often enough to keep it clean. The use of some implement, such as the duckfoot cultivator, that destroys weeds but leaves the ground in a lumpy condition is desirable. The lumpy condition facilitates the penetration of water and protects against soil blowing. Usually three cultivations keep the land free from weeds during the entire summer, though the number required to do this differs with the season. Timeliness is very important, since weeds are more easily destroyed when they are small. Fallow requires the use of the land for 2 years to produce one crop and consequently is expensive. This operates against its use where land is high priced or acreages are limited.

Green manuring is the most expensive method that has been tried. It involves the preparation of land for the green-manure crop, the cost of seed and seeding, the plowing under of the green-manure crop, and keeping the land free from weeds the rest of the season. Usually 2 plowings, at least 2 diskings, and 2 or more harrowings are required. The loss of the land for a year is also an item of expense in preparing land by this method.

SMALL GRAINS

Results at both stations indicate clearly that the most profitable crops of grain are produced by the cheaper methods of soil preparation. Grain on disked cornland or on disked land where some other cultivated crop has been grown has shown the highest net return under any method of soil preparation that has been tried. This is due largely to the low cost of production, but partly to the fact that disked cultivated land has generally produced yields above the average. The yields of wheat, oats, and barley on disked cornland have been higher than the yields of the same crops on spring-plowed or fall-plowed cornland. It must be borne in mind that the corn ground had been kept free from weeds. If weeds had been allowed to grow, the results probably would not have been so favorable. If the corn ground is kept clean, producing grain on the disked cornland is by far the most profitable method that has been tested.

Spring plowing and fall plowing are about equally desirable as methods of land preparation for grain. Practically the same amount of labor is necessary in preparing a seed bed under each method, and when seeding is done at the same time the yields produced are nearly the same. Fall plowing can be done at a time when work is not so pressing and has an advantage over spring plowing in that respect. Since seeding can be started as early as plowing, fall-plowed land can be seeded earlier than land that must be plowed in the spring. This fact becomes most important in seasons when unfavorable weather conditions hinder spring work, and provides a decided advantage for fall plowing, because early seeded crops mature earlier and as a result often escape periods of drought that injure later seeded crops. However, the land is usually dry after harvest, and, unless there are fall rains, the soil may be so hard and dry that the cost of fall plowing is prohibitive. When this is the case plowing in the early spring assures returns as good as if the land had been plowed in the fall, if seeding is not unduly delayed. Grain on early fall plowing generally makes a better early start than grain on spring plowing, but in years of drought this frequently is responsible for earlier firing of the grain on fall-plowed land.

Where land is cheap, disking in one crop of small grain on grain stubble is frequently advisable. Disking in grain continuously for a number of years results almost inevitably in a great increase in the number of weeds and a consequent reduction in yield.

Plowing is more expensive than disking in preparing land for grains. When small grain follows corn, better crops are obtained by disking. In the sections of western South Dakota where grain growing is most successful and where the quantity of grain to be grown greatly exceeds the area of cultivated crops, plowing part of the grain stubble for grain is recommended. The use of power in farming and the consequent increase in the cultivated acreage have generally increased the proportion of grain that must be planted following grain.

The yields of small grain on listed land compare favorably with those on plowed land. The cost of producing a crop on listed land is slightly lower, and the net return is a little higher. The difference in return is not great enough to justify the purchase of any special equipment for growing grain on listed land. Noxious weeds appear to become established on listed land more readily than under other methods of cultivation, and no doubt would eventually cut yields down.

Summer-fallowing has not increased the total yield of crops, but its use has resulted in a better distribution of yield among years. When machinery was horse drawn, the fallow was not advocated because of its greater expense. Power farming has brought about two changes that tend to make fallowing more practicable. The first is the material reduction in the cost of keeping land fallow. The second is the fact that greater acreages can be handled, and the proportion of grain to livestock has become higher. Fallow has a place in the cropping system on many farms as a possible insurance against failure and as a method of controlling weeds. It cannot be used profitably on farms where a large number of livestock are carried. It is of value on farms where grain growing is the chief enterprise and where, without fallow, a large percentage of the grain acreage would follow grain. Fallow, if used, should replace a portion of the grain following grain. When so used, fallow tends to stabilize production, as is shown in the results at the two stations.

At the station at Newell there were 2 years from 1909 to 1930 in which wheat under all methods of tillage was a total failure because of drought. There were only 2 other years in 22 in which the yield on fallow fell below 10 bushels per acre, but wheat after wheat fell below 10 bushels 8 times. Oats on fallow fell below 20 bushels in only 4 out of 22 years. Oats following oats yielded less than 20 bushels in 8 of the 22 years. Barley yielded less than 15 bushels 5 times on fallow and 9 times on continuous cropping.

At Ardmore, excluding the 2 years when the entire crop was destroyed by hail, there was only 1 year from 1913 to 1930 in which the yield of wheat on fallow fell below 10 bushels per acre. During the same period wheat after wheat fell below 10 bushels per acre in 9 of the 16 years. Oats on fallow fell below 20 bushels per acre in 2 of the 16 years. Oats after oats yielded less than 20 bushels in 9 of the 16 years. Barley on fallow fell below 15 bushels per acre in 3 of the 16 years. Barley after barley produced yields of less than 15 bushels in 8 of the 16 years. All of the low yields of barley on fallow occurred before the White Smyrna barley was grown in the rotations.

The greater benefit from fallow at Ardmore apparently lies in the fact that the soil at Newell is shallow and not capable of holding as much water as the soil at Ardmore. It is believed that the response to fallow on soils readily penetrated by moisture and roots to a depth of at least 4 feet would be as great in the section represented by Newell as at Ardmore.

The use of green-manure crops has not been profitable in grain production and is not recommended for any section of South Dakota. The yields have generally been lower than those on fallowed land, and the cost of production has been higher.

Subsoiling and deep tillage have neither increased nor decreased yields to a measurable extent. They have added greatly to the cost of production without adding to the value of the crop, and have been less successful than other methods of cultivation. The same labor distributed over more acres would be more profitable.

CULTIVATED CROPS

Spring plowing and fall plowing have given about equal results as methods of soil preparation for corn. Fall plowing requires a little more cultivation, because some spring cultivation is necessary in order to keep the land clean until the corn is planted. It has a slight advantage in that the corn usually comes up a little sooner and matures just a little earlier. There is no great difference in yields, and the cornland may be plowed at any time before planting without the yield being materially affected.

Listing for corn has given lower yields than either spring plowing or fall plowing at both Ardmore and Newell. The lower cost of land preparation, however, makes the net profit per acre nearly as high. In spite of this, listing is not likely to meet with favor in the heavier soils of western South Dakota. The tendency of the soil to crust after heavy rains sometimes results in a loss of stands on listed land. In all cases the corn comes up a little more slowly and matures a little later than on plowed land. For this reason it does not usually suffer so early from drought as under other methods of cultivation, but is less productive in good years. In lighter soils listing is proportionately more effective than on heavy soils and is as profitable or more profitable than plowing for corn.

The more intensive methods of tillage have shown less response with corn than with small grains.

Fall plowing has been superior to spring plowing as a method of land preparation for sorgo. The difference has been largely due to the stand obtained. Spring-plowed land of the heavy clay type cannot always be worked down to form a good seed bed for sorgo, because of its tendency to remain lumpy until mellowed by rains. In seasons that are dry between plowing and planting time, the fine seed bed necessary to give a good stand of sorgo cannot be obtained.

HAY CROPS

Hay crops, such as alfalfa, bromegrass, and crested wheatgrass, are not adapted for use in rotations. They should be seeded in spring or early summer on land plowed in the fall, worked down to form a solid seed bed in spring, and kept free from weeds until seeding. After a stand of these crops has been obtained, they should remain intact so long as the production remains good. Bromegrass may be pastured to good advantage for several years after it becomes so sod bound that it no longer produces a profitable yield of hay. Crops following alfalfa and bromegrass are usually poor, on account of the extremely dry condition in which the soil is left.

THE BEST SYSTEM OF FARMING

The system of farming that offers the greatest possibility of a permanent agriculture for western South Dakota combines crop production with the raising of livestock. The more certain crops, such as corn stover and sorgo, cannot be grown with profit unless fed near where they are produced. Their bulky nature prevents long hauls, and their sale price is far below their feeding value. The production of livestock alone is likewise subject to limitations, the most important being the question of winter feed. In dry years the growth of grass on the Great Plains is scant, larger acreage is needed for pasture, and the quantity of hay that can be cut is limited. The best way to meet this condition is to grow some annual crop, such as corn or sorgo, that produces a comparatively large bulk of rough feed per acre.

The system of farming that suggests itself is as follows: (1) The production of livestock up to the limit of dry-year pasture, (2) the planting of an acreage of corn sufficient to meet the winter demands of the stock to be carried over, and (3) the production of small grain on the cornland.

The principal limit of livestock production for any one farmer is the area of pasture land he has left after an acreage sufficient for growing crops has been set aside. The number of livestock to be kept should be limited by the extent of pasture available in a dry year rather than that available in a favorable season. It is better to undergraze land in good seasons than to overgraze it in years of drought. The carrying capacity of different sections differs with the native vegetation. The carrying capacity of any particular section must be determined through observation and experience.

Corn stover offers a solution of the question of winter feed. Corn and sorgo can practically be relied upon to furnish the rough feed each year. Ear corn is produced in paying quantities in more than half the years and when obtained can well be utilized either for feed or for sale. Since corn grows well on either spring or fall plowing, the work preparatory to planting can be done at the time when it interferes least with other farm work. The acreage of corn and sorgo grown should be sufficient to insure winter feed for the livestock to be carried over. The acreage should be fixed by the quantity necessary for winter feed in years when the production of stover is not high. In years of extra heavy production the excess feed can be carried over or the number of stock increased for winter feeding.

Small grains can be grown in connection with livestock farming with the chances of success very good and the chance of total failure low. The corn ground provides one of the best-prepared seed beds for small grains, one on which they can be grown at a very low cost.

The land planted to corn one year may be planted to small grain the next, without expense other than for the seed and for disking, harrowing, and seeding. In some years when it seems apparent that no grain will be produced, the small-grain crops may be cut for hay and will provide a supplemental supply of winter feed. This makes the grain crops valuable even in seasons when their production for grain is a failure. As has been stated, the corn should be kept clean. The cost of keeping the corn free from weeds is more than made up in the added value of the crop that follows. The kind of small grain to be raised must depend upon the needs of the individual farmer.

With modifications this system of farming should be adapted to any part of western South Dakota. In most parts of western South Dakota the acreage of small grains may exceed that of corn. The extra acreage of small grains will then be grown on spring-plowed, fall-plowed, or disked grain land. The disking is advocated for heavy land where the cost of plowing is great. Even such land would not be disked unless it were relatively free from weeds. When the land to be seeded to small grains is more than double that planted to a cultivated crop, enough of the small-grain acreage may be replaced by fallow so that small grain will not follow small grain more than one year. Replacing a portion of the grain acreage with fallow offers a better distribution of yield among years, a better distribution of labor, and a more effective control of weeds.

Under highly efficient management grain production alone, on an extensive scale and by mechanized agriculture, offers a possibility of success. Fallow is an integral part of such a system of farming in western South Dakota. The general plan for such a system would be to have a third of the acreage in fallow, a third in grain on fallow, and a third in grain seeded in disked stubble. The fallow would be plowed in May or early June, worked only enough to control weeds, and ridged in the fall at right angles to the prevailing winds to prevent soil blowing.

The climatic records cover a much longer period than those of crop production. They show that years of such extreme conditions as those of 1911 are very infrequent. Such years, as well as those of less extreme conditions like those of 1919, may be provided against in part by a liberal carry-over of surplus feed from years of heavy production. They must be met in part by the importation of feed and in part by the temporary reduction of herds and flocks. The essential thing is that farms must be backed by sufficient capital so that they can stand the strain of such reverses and continue as going concerns prepared to obtain the returns of the good and the average years.

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U.S. GOVERNMENT PRINTING OFFICE: 1933

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A 1.9: 1164

THE FARM LEASE CONTRACT

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FARMERS' BULLETIN 1164

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of
Farm Management and Farm Economics
H. C. TAYLOR, Chief

Washington, D. C. October, 1920

Additional copies of this bulletin may be obtained free from the
Division of Publications, U. S. Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

YOUR FARM LEASE—

WAS ITS FULL MEANING understood before it was signed?

Is it so written that its meaning will be clear at any later time?

Is it fair to both parties?

Does it give the tenant a reasonable opportunity to make a comfortable living and to get ahead?

Does it require proper and conservative care of the premises leased?

Are all desired reservations to the lease made?

Are the things stated which each party is to do and to contribute?

Does it make clear the rights and privileges of each party?

Does it define the relationship between landlord and tenant and provide for the settlement of differences of opinion?

Does it contain a statement of the procedure to be followed when the relationship of landlord and tenant is to be terminated?

Does it contain the following essentials to a legally complete lease?

1. The date it was made.
2. The names and the final signatures of the contracting parties.
3. The period for which the lease is to run.
4. A description of the property leased.
5. An agreement in respect to the amount of rent to be paid and the time when and the place where it is to be paid.

THE FARM LEASE CONTRACT.

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IMPORTANCE OF CONTRACT.

THE IMPORTANCE of the subject of this bulletin is indicated by the fact that 37 per cent of all farms in the United States were operated by tenants in 1910, while 9.3 per cent were operated by owners renting additional land. Part or all of the land and improvements of about 3,000,000 farms was rented. Since the great majority of lease contracts are for one year, and since the average period which the tenant remains on a farm is about three years, it is probable that each year about 2,000,000 lease contracts must be made or renewed.

Some students of the land question believe that even in an ideal system of land tenure a considerable proportion of tenancy would be desirable provided that the relationship of landlord and tenant were such as would insure good farming, the conservation of the soil, a fair division of the product, and a progressive community life of which the tenant is an essential part.

It is too much to expect that such a desirable relationship can be established merely by improvement of the lease contract, but it must be admitted that since the lease agreement is the basis of the relationship between landowner and tenant, a careful consideration of its terms may have much to do with promoting harmony and mutual satisfaction, lengthening the period of occupancy, and improving the methods of farming rented land.

Throughout the United States the terms of lease contracts vary so much in accordance with differences in type of farming and other local conditions that it is impossible in a single bulletin to furnish detailed instructions that will apply to all these varied conditions. The discussion of the leasing system suitable for a given type of farming—such as dairy farming, grain farming, cotton farming, or fruit farming—will require an entire bulletin.

However, there are many considerations common to all leases, no matter what the type of farming. The object of the present bulletin is to discuss some of these common considerations and particularly to provide a list of points that may need to be considered in the making of a satisfactory lease contract. It has been the experience of many farmers that in the making of such a contract one is likely to overlook or omit some essential points unless he has available memoranda to remind him of all the matters that should be considered.

THE PRINCIPAL KINDS OF LEASE CONTRACTS.

The majority of farm leases fall into a few main classes according to the method of rent payment, namely, cash, standing rent, share, share-cash, and stock share.

In cash renting the landlord furnishes only the real estate, usually paying taxes and at least the money costs of upkeep. The tenant furnishes working capital, bears all operating expenses, and receives all the income after paying a fixed amount of cash as rent. The landlord does not assume any of the risks of farm operation, and usually undertakes no responsibility for management except such supervision as may be necessary to see that the land and improvements are not abused. Obviously the system may prove advantageous to a landlord who, for any reason, can not give much attention to the business of farming, and it may be preferred by the tenant who has sufficient capital and experience to operate without assistance from the landlord and who does not wish to share the profits of superior management with another.

Standing rent—sometimes called "lint rent"—is a modified form of cash rent. The tenant agrees to pay so many bushels of grain or so many bales of ginned cotton for the use of the farm. The landlord gets the same amount no matter how large or how small the crop. Consequently he is freed from the risk of loss due to bad seasons or bad management and, therefore, from the necessity of assuming responsibility for the management of the farm. Unlike true cash rent, however, the actual rent received by the landlord in the system of standing rent is subject to variation due to changes in the prices of the products received as rent.

In share renting the landlord receives a share or fraction of all or of certain crops and sometimes also of live-stock products and increase of live stock. More generally than in renting for cash or for a standing rent, he also pays some of the expenses of production. There are numerous variations in different parts of the country and with different types of farming with regard to the contributions and receipts of the respective parties. Because of the greater complexity of the share-renting contract and also because the system of share renting is more generally employed in the United States than any other system of renting, such contracts being twice as numerous as those for cash renting and renting for a fixed amount of the crop combined, more attention is devoted to it in this bulletin than to other forms of renting.

One of the chief reasons for the popularity of the share-rent system among landlords is the greater control which this system gives them over their farms, as compared with the cash-rent system. Another reason is that the landlord stands to realize every year a rental which is directly proportionate to the production and prices of the year. His profit being proportionate to the success with which the farm is worked, it behooves him to give more freely of his experience and capital toward its improvement and proper management than he would do if the place were worked by a cash tenant. Tenants who have little capital and experience can often do no better while acquiring these advantages than to take a farm on shares from an experienced landlord who is prepared to supply a part of the working capital, to exercise a considerable amount of supervision, and to share the risks of the business. On the other hand, if the farm is unusually small or infertile, the tenant may find it unprofitable to rent at the customary share and decline to work the place except on a cash-rent basis.

Stock share renting is a form of share renting in which the landlord and tenant share the ownership of all or part of the productive live stock, usually half-and-half, sharing the expenses and receipts in the same proportion. The general advantages and disadvantages of the system for each party are somewhat similar to those in ordinary share renting. Stock share renting fosters general live-stock farming and encourages the utilization on the farm of feedable grains and other crops. It usually results in a close association of the landlord with the business and often approximates the character of a business partnership.

Another modified form of share renting is the share cash system. Usually this consists of sharing the more important crops, but the tenant pays cash rent for pasture or occasionally for buildings, use of garden, or other special advantages. Usually the system is superior to the share system proper in that the landlord, because of the cash rent feature, is more willing that the tenant should increase the acreage in pasture and consequently engage in live-stock farming to a greater extent than would be the case if the landlord received only a share of the crops and nothing for use of pasture. In some cases the cash rent, or a part of it, is in the nature of a bonus paid in addition to the usual share rent, because of a marked increase in the annual value of the farm.

A form of share renting commonly known as "cropping" or the "cropper system" in cotton and tobacco producing regions, superficially resembles the system of share renting already described in that the cropper pays the landlord a share of the crop. However, the cropper usually contributes nothing but human labor to the enterprise, and under the laws of a number of States is considered a laborer rather than a tenant. The majority of croppers are subject to supervision by the landlord and are dependent on him not only for the capital needed for putting in the crop, but also for living expenses while the crop is being produced.

Because the landlord assumes a greater amount of the risk, and usually a greater amount of responsibility for supervision under the various forms of share leasing, he should receive a somewhat larger net return per acre than under cash leases. Belief that this is the case has been confirmed by most of the farm income surveys that have been made.

POINTS TO BE CONSIDERED IN THE FARM LEASE.

The following is a list of points that may need to be considered in the making of the farm lease. While it does not cover all possible points, it does contain the more common and the more important considerations. Since cash renting is much simpler than renting on shares, there are many points in the list which do not apply to cash leases.

I.

GENERAL DETAILS.

1. Date lease is made.
2. Names and formal designations of landlord and tenant.
3. Number of years lease is to run and dates of beginning and ending.
4. Statement of manner by which the lease is to be terminated or renewed.
5. Brief description of the real estate leased, including name of farm, boundaries, and location with respect to State, county, township, and section.
6. Description of other property included with the real estate in the lease.

II.

RESERVATIONS.

1. Right of entry by the landlord for purpose of inspecting buildings and other improvements, crops, and live stock, for making repairs and improvements, for work in connection with crops of the following harvest and for other purposes.

2. Reservation by the landlord of parts of buildings, granary space, corn cribs, mow space, and any other portion of the real estate the use of which it is agreed he shall reserve.

3. Reservations and restrictions with respect to the use of pasture, fruit, woods, timber, sand pits, gravel beds, fish, and game.

4. Reservation of the right to decide or direct farming operations.

5. Reservation of the right to buy or sell live stock, crops, produce, or supplies for farm use.

6. Limitations on the kind, amount, or value of property which may be bought or sold without informing the landlord and getting his consent.

7. Designation of a bank in which undivided funds are to be kept or deposited, with agreement as to the disposition or use of these funds.

8. On share rented farms, a statement denying, acknowledging, or limiting partnership relation.

9. Reservation of the right to sell the farm, with statement of adjustments to be made in case of sale.

III.

ASSURANCES AND GUARANTIES BY THE TENANT.

1. To operate the farm in a good and farmerlike manner.

2. Not to sublet the farm.

3. To occupy the farm continuously throughout the lease period.

4. Not to attempt to operate outside land in addition; not to thrash for outsiders as a business nor to give preference to any other work over the operation of the farm.

5. To work for the landlord if requested, at specified rates, when not engaged in work on the farm.

6. To commit no waste or damage, and suffer none to be committed; to protect and care for the buildings, fences, trees, and other property.

7. To make inventories at stated periods and to keep records of farm yields, acreage, purchases, sales, breeding of live stock, and to give the landlord access to these records.

8. To yield peaceable possession at the termination of the lease.

9. Not to bring on the premises mortgaged property that may have the effect of impairing the landlord's lien.

IV.

ASSURANCES AND GUARANTIES BY THE LANDLORD.

1. To make concessions with respect to rent and other obligations of the tenant in the event of disaster to the farm operations as the result of fire, flood, drought, pestilence, or other conditions over which the tenant has no control.

2. To provide peaceable possession, or to protect the tenant's interests, in event of litigation or seizure of the landlord's title by a mortgagee or other claimant.

3. To release to the tenant the residue of crops, live stock, and other products remaining after the rent or rent share is paid and the landlord's lien satisfied.

V.

AGREEMENTS WITH RESPECT TO CREDIT FURNISHED BY THE LANDLORD.

1. Terms on which the landlord is to make advances of money or supplies to the tenant for the purpose of operating the farm.

2. Special and occasional credits to make possible the purchase of live stock and feed, or with respect to the feeding of crops to live stock.

3. Terms of loans on farm implements, work stock, productive stock, or other property of which the tenant is to be the nominal owner or part owner.

VI.

RESPECTIVE CONTRIBUTIONS BY EACH PARTY TO OPERATING CAPITAL.

1. General farming machinery, running gear, small tools, and harness, with provision for replacement and repair.

2. Special farm machinery not commonly employed, such as manure spreader, lime or fertilizer distributer, spraying outfit, silage cutter and engine, milking machine, gasoline engine, thrashing machine, tractor and tractor equipment, with provision for replacement and repair.

3. Horses and other work stock.

4. Productive live stock, including cattle, hogs, sheep, and poultry.

VII.

ADJUSTMENTS WITH RESPECT TO PROPERTY OWNED IN JOINT ACCOUNT.

1. Method of appraising the value of property of either party taken over for joint account.

2. Method of dividing property jointly owned at termination of lease.

3. Settlement for undivided crops, products, or supplies used by the tenant in his household, for his horses or other stock.

VIII.

RESPECTIVE CONTRIBUTIONS BY EACH PARTY TO EXPENSES.

1. CONTRIBUTIONS OF LABOR AND SPECIAL SERVICES:

(*a*) Amount of labor to be contributed by each party to general farm work.

(*b*) Special arrangements with respect to the employment of members of the tenant's family.

(*c*) Arrangements with respect to extra hired labor and labor engaged in thrashing, silo filling, baling, shredding, clover hulling, and other operations involving the employment of machines not owned by the tenant.

(*d*) Responsibility of the respective parties with regard to hauling and delivery of crops, milk, and other farm products, hauling supplies for farm use, hauling tile, sand, lumber, fencing, and other materials used in making farm improvements.

(*e*) Furnishing of skilled labor or unskilled labor employed in fencing, tiling, repair or construction of buildings, drilling of wells, or other work of farm improvement.

(*f*) Contribution of labor employed in mowing, grubbing or pulling weeds and brush, cleaning ditches and drainage outlets.

(*g*) Contribution of labor employed in keeping up fences and in incidental patching and repairs to improvements.

(*h*) Arrangements for the board and lodging of outside labor, particularly of labor employed by the landlord on farm improvements.

2. EXPENSES ON ACCOUNT OF LIVE STOCK:

(*a*) Use of feed purchased or produced on the farm. What stock may be fed from undivided feed and what stock may not be so fed. Limitations on the amount of undivided feed which may be used for different classes of stock or on the number of stock which may be fed.

(*b*) Breeding and veterinary fees; cow testing, registration, and exhibition fees; live-stock insurance; horseshoeing and other incidental expenses in connection with productive live stock or work stock.

(*c*) Sharing of losses from injury, depreciation, or death of live stock.

3. OTHER EXPENSES:

(*a*) For seed, including grass, clover, alfalfa, and cover crops, general farm crops and plants used in the raising of truck crops, small fruits, and tobacco.

(*b*) For setting out or caring for fruit and ornamental trees and hedges.

(*c*) For barrels, boxes, crates, bags, bagging, baskets, cans, and other containers.

(*d*) Manure, lime, phosphates, and other fertilizers.

(*e*) Spray material for field crops and fruit trees, material for treatment of seed and inoculation of soil for legumes.

(*f*) Machine bills for thrashing, ginning, shredding, baling, silo filling, clover hulling, and corn shelling.

(*g*) For coal, gasoline, and oil for farm use, binder twine.

(*h*) For telephone.

(*i*) Storage, freight, buying, and marketing costs.

(*j*) Insurance on farm crops, feed, supplies, and implements.

(*k*) Taxes on property other than real estate, water assessments, and irrigation ditch upkeep.

(*l*) Real estate insurance and taxes, including school and road taxes.

(*m*) Expenses for hiring additional pasture and other land outside of the regular farm area.

IX.

PAYMENT OF RENT.

1. Cash rent for entire farm or portions thereof, with specifications as to amount, time, and place payable.

2. Rent payable in terms of a fixed quantity of a farm product, with specifications as to amount, quality, time, and place payable.

3. Rent share of the various farm products with specifications concerning time, place, method of division, and responsibility of tenant for delivery.

4. Specified quantities of milk, butter, eggs, firewood, feed, fruit, and other products for landlord's household use, and arrangements with respect to delivery of the same.

X.

PRIVILEGES FOR WHICH SPECIAL RENT IS OR IS NOT TO BE PAID.

1. The farmhouse, habitation for laborers, and buildings for live stock, tools, and crops harvested.

2. Garden spot and pasturage for limited number of stock.

3. Use of small areas of land for raising special forage crops.

4. Use of fruit, firewood, milk, eggs, butter, and other products for tenant's household, or for laborers.

5. Use of undivided grain, hay, or other crops for live stock kept by the tenant for his personal advantage.

XI.

SPECIFICATIONS WITH RESPECT TO THE CARE, USE, AND IMPROVEMENT OF REAL ESTATE AND ARRANGEMENT FOR LABOR AND MATERIALS USED OR NEEDED FOR THESE PURPOSES.

1. Fruit, shade trees, forest trees, and down timber.

2. Drains, ditches, bridges, and roads.

3. Time, frequency, and manner of mowing weeds and brush in pasture, along roads and fence rows, and about buildings.
4. Windmill, engine, and pumps.
5. Buildings, fences, and gates.

XII.

SPECIFICATIONS WITH RESPECT TO FARMING METHOD AND PROCEDURE.

1. Specifications as to acreage, location, and rotation of various crops.
2. Enumeration of crops which may not be raised.
3. Special regulations with respect to the method of growing each crop, including the details with respect to preparation of the land, time and manner of planting, kind of seed, method of manuring or fertilization, subsequent care, harvesting, storage, and marketing, or time and manner of division.
4. Limitations or restrictions on the sale or removal of crops, on the pasturage of crops, and on the burning or removal of straw, fodder, manure, etc.
5. Number and kind of live stock to be kept and the upper and lower limits of the same.
6. Regulations with regard to the number of stock which shall be allowed to run on pasture and times when pastures may or may not be used.
7. Provision for the ringing of hogs and prohibition of the keeping of breachy live stock.

Specifications respecting the methods of farming and the procedure to be followed may be made clearer if, in making them a part of the lease, they are accompanied by a map of the farm. Such a map may show such details as the use made of the land in past years, previous rotation system, present use of the land, rotation to be followed in the future, the drainage system, past and present policies with respect to clearing, liming, manuring, and fertilizing.

XIII.

PROVISION FOR SUPERVISION.

1. Provision with respect to kind and extent of supervision for which each party will be responsible.

XIV.

PROCEDURE AT TERMINATION OF LEASE.

1. Disposition of crops growing, unfed or unsold, or of feed and supplies remaining on hand.
2. Disposition of farming equipment, work animals, and other live stock owned on joint account.
3. Specification of number of acres which must be left plowed, seeded down, planted in wheat or other crops, or in pasture.
4. Compensation for improvements made by the tenant, including construction of buildings and fences, digging of wells, drainage work, clearing of land, setting out trees and small fruits, planting of hops, asparagus, rhubarb, or other perennial plants.
5. Compensation for unexhausted additions made by the tenant to the fertility of the soil.
6. Authority for removal of improvements made by the tenant without assistance or compensation by the landlord, such as fences, hog houses, corn cribs, water troughs.
7. Settlement of outstanding indebtedness.

XV.

ENFORCEMENT OF CONTRACT.

1. Provision for the settlement of disputes and differences of opinion by arbitration or otherwise.
2. Provision for fulfillment of terms of the contract by heirs, executors, administrators, or assigns, in the event of death or disability of one or both parties.
3. Conditions that will constitute a forfeiture of the lease, and method of determining rights of landlord and of tenant in the event of termination by forfeiture.
4. Provision for penalty to be paid by either party according to a stated scale in the event of failure to perform certain agreements in the contract.
5. Right of the owner to have work which is neglected by the tenant performed at the tenant's expense.
6. Acknowledgment of the existence of a lien to secure to the landlord the payment of the rent and the performance of specified agreements.

XVI.

FINAL DETAILS.

1. Signatures of the parties and their witnesses.
2. Sealing and recording.

DISCUSSION OF PROBLEMS COMMON TO ALL KINDS OF FARM LEASES.

FORM OF THE LEASE.

A written lease is more satisfactory than a verbal one. If one of the parties should die, a written contract protects his estate from false claims by the other party. A written lease is likely to be more carefully considered by both parties, and its terms defined with greater precision. Moreover, it serves as a memorandum to both parties, so that the actual terms of the contract may not easily be forgotten. In practically all of the States the statutes provide that a lease for a period longer than that specified by statute (commonly three years) shall be considered as creating only an estate at will, unless the contract is in writing and unless it complies with the requirements specified with regard to signatures, witnesses, or other formalities.

Standard printed forms for farm lease contracts may often be obtained from printing establishments, stationers, lawyers' offices, and banks. Such forms usually contain insufficient space for the numerous special conditions of a complicated farm lease. However, a standard lease form may be of assistance in providing legal terminology and such legal specifications as may be peculiar to the law of the State. It is desirable that the landlord and tenant agree on the terms of the contract and then prepare a lease embodying these agreements. After the terms of the lease are agreed upon an attorney may be consulted, if desired, to aid in giving the correct legal form.[1]

The legal essentials to the validity of a lease contract are definite agreements as to (*a*) the extent and bounds of the property leased; (*b*) the term of the lease; (*c*) rate of rent, together with specifications of time and method of payment. It is not usually necessary that a lease contract be recorded in order to be valid, but recording may have the advantage of serving notice to third parties of the existence of the contract. However, in probably a majority of the States the physical possession of the property by the tenant is held to constitute notice to third parties of his rights in the property.

DESIGNATION OF PARTIES.

In framing any legal contract it is important to designate accurately the respective parties. It is customary to use the terms "party of the first part" and "party of the second part" to designate the respective parties. If one of the parties comprises more than one person, the expression should be plural—as, for instance, "parties of the second part." In order to shorten and simplify the contract it may be well to define the meaning of these expressions at the beginning of the lease. Such a definition may read as follows:

> This agreement, made this first day of March, 1920, between John Smith, party of the first part, hereafter called "the landlord," and Richard Brown, party of the second part, hereafter called "the tenant," witnesseth, etc.

LENGTH OF LEASE PERIOD.

One of the most important questions to be determined is the proper length of the lease period. In the United States farm leases have been predominantly of short duration, the majority for one year. In England there were many experiments during the early part of the nineteenth century with leases of from seven to twenty-one years in length, and Scotland continues to be a country of long leases. However, it has become customary in the latter country to modify the long lease by provisions for terminating the lease at certain definite times during the period of the lease by giving sufficient notice, as, for instance, at the end of the second, fourth, or sixth year. In England long leases have generally given place to the one-year lease with guaranty of compensation for improvements in accordance with the provisions of the agricultural holdings acts.

These extensive experiences have shown clearly the advantages and disadvantages respectively of long and short leases. In the case of long leases for cash rent the actual cash rental value of the land may become out of line with the rent specified in the lease on account of changes in prices and other conditions. Such objection to long-term leases is overcome in part, if not entirely, when the rent is a share or a fixed amount of the crop. The landlord may be prevented from taking advantage of favorable opportunities to sell the land unless the lease contains a clause permitting sale. Such a clause, however, tends to nullify the long-term character of the lease unless accompanied by provisions for compensating the tenant substantially for termination by sale. Experience in England showed that tenants often found it to their personal advantage to use the land to its detriment in the last years of a long lease, and it was necessary to introduce clauses carefully restricting the method of farming in the last years of the contract. Still another objection to the long lease is that while it is binding on the landlord, it may have but slight binding effect on the tenant who has little property.

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[1] In the following discussions forms of statement for various kinds of clauses are included. However, these are for illustration and it is not advised that they be rigidly followed.

The long lease enables the tenant to undertake extensive improvements such as liming or tiling, and to engage in systems of rotation covering a considerable period of years, without fearing that the fruits of his labor will be lost through the termination of the lease. However, this advantage may be obtained under the short lease when the lease contains provisions for compensating the tenant for unexhausted improvements made by him.

The short lease has great advantages for both parties because of its elasticity. We live in a country of rapid changes, and it is doubtful if any considerable number either of landlords or of tenants would care to be bound by lease contracts of long duration. Moreover, short leases do not necessarily imply short tenures. Such statistics as are now available appear to indicate that in the United States tenants under one-year leases have occupied the farms leased for a greater number of years than those whose leases were for longer periods.

In fact, there is even greater reason in the United States than in England for short tenures. Land in America changes owners much more frequently than land in England does. In England many landlords have only a life estate in the land and not the right to sell. England is predominantly a land of cash renting, while in the United States more than twice as many farms are rented on shares as for cash. Since the amount of the landlord's share depends largely on the efficiency of the tenant the former is not likely to want to enter into a contract for a long period until he is sure of the tenant's efficiency. Moreover, because of the comparatively intimate relationship that usually exists between landlord and tenant in share farming, the success of the enterprise depends to a large extent on the personalities of the two parties and on their ability to work together harmoniously. Many of the young tenants are compelled at first to rent inferior farms, and desire to retain them only until they can obtain better ones.

For these reasons it is probably wise to start with a one-year lease, but with a clause providing for renewal. Such a clause for a lease terminating March 1 may read as follows:

> The second parties shall have the privilege of notifying the first parties in writing on or before the first day of September, 192—, that they have elected to renew this lease for the second year, and such election shall be binding upon the first parties unless they notify the second parties in writing on or before October 1, 192—, that they do not desire a renewal of this lease on their part. If the lease is renewed, the same right of election shall apply to the year 192—.

After the two parties have become thoroughly acquainted and it has become clear that they can work together harmoniously and effectively, it may be desirable to enter into a lease contract of sufficient length to enable the tenant to engage in systematic farm improvement involving the investment of capital and labor for which an immediate return will not be forthcoming. Some of the disadvantages of the lease for a period longer than one year may be overcome by clauses providing penalties for nonfulfillment of contract and for annulment of contract in extreme cases. (See pp. 16, 23.) Likewise it may be provided that either party may dissolve the arrangement by paying compensation to the other party to an amount specified in the lease. This enables either party to escape from fulfilling the complete period of the lease if emergency makes it desirable. Such a dissolution, however, should not be permissible except at the end of the farm year, nor should it be permissible except on the fulfillment of those contract provisions which would have to be fulfilled at the termination of the regular period of the lease, such as compensation for unexhausted improvements made by tenant and for unharvested crops.

Whether the lease should be for one year or for a longer period is likely to be determined in part by circumstances. Thus, when the landlord furnishes all the operating capital, makes all the improvements at his own expense and provides for the maintenance of fertility, there may be little reason for a lease running longer than one year. On the other hand, when the contract calls for the clearing of land by the tenant in return for the free use of it or for use at a nominal rent, a lease of at least five or six years may be necessary. Similarly, when the tenant is expected to plant a considerable acreage in fruit or in perennial crops, a term of several years may be desirable. In fact, any lease contract which requires a considerable investment of irremovable capital on the part of the tenant may necessitate either a lease of considerable duration or agreements for compensation at termination for unexhausted improvements made by the tenant. It should not be assumed, however, that either a long lease or provision of compensation for unexhausted improvements will alone induce good farming. While the absence of both arrangements may tend to discourage an efficient tenant from pursuing sound methods of agriculture, other provisions in the lease may be necessary to compel the inefficient and improvident tenant to employ such methods. Where such is the case specific requirements concerning the system of farming should be accompanied by stipulations permitting careful supervision on the part of the landlord.

DATE OF BEGINNING.

The date of beginning the lease year differs in various sections of the country, but is usually made to coincide with the time of year when the more important crops have been harvested and sold and before preparations for crops of the following harvest begin. In the Corn Belt, March 1 is the customary date; in the South, January 1; in regions where winter wheat is the principal crop, August 1.

DISAVOWAL OF PARTNERSHIP RELATION.

The relationship of landlord and tenant is not ordinarily that of a partnership. The latter involves joint liability to an unlimited extent for all debts created by either party in the name of the firm, equal voice in the management of the business, and other conditions not characteristic of the relation of landlord and tenant. Because the terms of many lease contracts, especially the so-called stock share leases, are of such a character as to suggest the actual relationship to be a partnership, it is sometimes customary to include a clause in the lease disavowing the partnership. It is generally held by the courts, however, that parties to an agreement can not prevent the creation of the partnership relation and its consequent bearing with respect to third parties, provided the agreement itself and the relations between the parties thereto possess the elements of a partnership. It is the facts that govern and not the name by which the parties denominate their relationship, so far as concerns the rights of third parties. However, such a clause may clarify the respective obligations of the parties to the contract with reference to one another.

A clause containing such a disavowal may read as follows:

> Said parties to this lease shall be in no sense partners. Neither shall bind the other to any obligations nor incur debts for the payment of which the other party might be liable without the written consent of that party.

CONTINUANCE OF LEASE AFTER DEATH OF EITHER PARTY.

In order to insure the continuance of the contract the following clause may be inserted:

> It is mutually agreed by and between the parties hereto that all the conditions and obligations of this contract shall extend to and be obligatory upon the heirs, successors, executors, administrators, and assigns of the tenant and upon the heirs, successors, executors, administrators, and assigns of the owner.

PROCEDURE IN EVENT OF SALE.

If a lease is but for one year, it is probably unnecessary that it contain a sale clause, but in case of a lease for several years such a clause may be inserted. The following will illustrate this type of clause:

It is hereby agreed that, in case of sale of said premises during the occupancy of said second party, and in case the purchaser should desire possession, said second party hereby agrees to give up to the said purchaser said premises at once on payment to the said second party of a fair and reasonable compensation for such surrender, and if he and the purchaser can not agree as to the amount of such compensation it shall be left to three disinterested appraisers, of whom said second party shall choose one, the purchaser one, and the two so chosen shall choose a third one. Their decision shall be final as to the amount to be paid by the purchaser to said second party.

ASSIGNMENT OF LEASE.

The assignment of a lease contract by one tenant to another is a matter of considerable concern to the landlord, for on the personal honesty and efficiency of the tenant may depend the amount of rent (in case of share contracts), the security of the rent payment, and the care of the property intrusted to the tenant. Although the assignment of a lease by a landlord is not usually a matter of great concern to a tenant, it is as well to include in the contract a clause forbidding such an assignment without the consent of both parties, as follows:

Except in case of sale, as provided above, this lease shall not be assigned or transferred to anyone unless on written consent of both parties, and no one but the party of the second part, his family, and hired help shall occupy the premises or any part thereof during the term of this contract, nor shall the premises or any part thereof be sublet without the written consent of the first party.

RIGHT OF ENTRY AND YIELDING OF PEACEABLE POSSESSION.

The landlord should reserve a right of entry, even when he does not participate in supervision of farm operations. Such a reservation may be expressed as follows:

The landlord reserves the privilege of going upon said farm at any time and at all times to look after his interests, to do work and to have work done, either personally or by agent, employee or employees, without being liable in damages.

Assurance of peaceable possession at termination of the lease may be provided for as follows:

The second party covenants and agrees with the first party that at the expiration of this lease, by limitation or otherwise, he will yield up possession of said premises in as good condition as they are at the beginning of this lease, natural wear and damage excepted, and that he expressly waives any and all notice to terminate, except as herein specifically required, and upon demand of the first party will pay ten dollars for each day the premises are occupied after such expiration unless the written consent of the landlord for such continued occupancy shall have been given.

PROVISIONS FOR CARE OF PREMISES.

Whether the land is rented for cash or for share rent the landlord should be interested in insuring the care and preservation of his land and improvements. Nothing will serve to accomplish this result so much as careful supervision by the landlord or his representative. However, the landlord's position may be strengthened if provision is made in the contract requiring the tenant to take proper care of the property intrusted to him. Such provisions may be in general terms or detailed. If the latter, there may be great differences in the actual provisions according to the special circumstances and terms of the agreement.

The following is a general clause which provides against unnecessary waste or damage:

> The party of the second part, the tenant, agrees that he will not commit or suffer to be committed any waste, damage, or strip of said premises, as, for instance, cutting wires, removing sections of fence, failing to oil pumps and windmills, or tearing down fences for purposes not required in the ordinary course of farming.

If the tenant is expected to keep buildings and fences in repair, as is generally the case, a clause such as the following may be written into the lease:

> The party of the second part agrees to keep the buildings, fences, and other improvements on said premises in as good repair and condition as the same are when he takes possession, or as good as they may be put in by the lessor during the term of the lease, ordinary wear, loss by fire, or unavoidable destruction excepted.

Among the details that may be specified with respect to care of the premises, are to keep the windmill and other pumping machinery properly oiled and cared for and to repair any damage to such machinery, except when damage is due to action of the elements; to take proper care of trees, ornamental vines and shrubbery about the buildings, in the yard and garden, and to prevent injury to them; to cut all hedges at least twice each season and to burn the brush if of considerable amount; to keep open all necessary ditches; and to keep buildings and fences in good repair. Other specifications having to do with the care of the farm land will be mentioned in the discussion of farming specifications. (See p. 19.)

REPAIRS TO BUILDINGS AND OTHER FIXTURES.

Which of the two parties should be responsible for the making of repairs will depend so much on the circumstances of the case that it is difficult to lay down a rule that always should be followed. In general it may be said that the tenant should repair all breakages and damages due to his own fault or to the special ways in which he uses the property. On the other hand, such repairs as would be necessary, even if the property were not in use, should largely be at the expense of the landlord. There will be other kinds of repairs between the two classes to which both parties should contribute.

IMPROVEMENTS.

The making of improvements, as distinguished from ordinary repairs, is supposed to add to the value of the farm, and the greater part of the expense should be defrayed by the landlord. However, if the rent is not raised as a result of such improvements the tenant will also benefit from them provided he enjoys sufficient security of tenure, in which case he may properly be expected to contribute toward the making of such improvements. The general practice is for the landlord to furnish all materials used, together with all skilled labor employed, and for the tenant to do necessary hauling of materials, to board the skilled laborers and to furnish occasional unskilled labor. If, however, the tenant is called upon to furnish any unusual amount of labor on the improvements or to furnish such labor at a time when it is needed for ordinary farm work he should be repaid for such labor at its actual cost to him. Some landlords agree with their tenants upon a wage scale to be followed in payment for special labor contributed by the tenant on the improvement of the farm. In all cases, however, the tenant's contribution should be determined by the amount of benefit he may be expected to derive as compared with benefits accruing to the landlord. Sometimes, as in the case of temporary fences constructed under a cash lease, nearly all of the benefit is to the tenant. Interior papering and decorating of the residence may largely benefit the tenant, and some landlords furnish the materials for such work if the tenant is willing to furnish the labor to do the work in a presentable manner.

INSURANCE.

It is usually the custom for the landlord to pay the expense of insuring buildings. Since fire insurance contracts may become invalid through failure of the insured party to protect the property insured against unnecessary hazards, it may be necessary for the landlord to include in the lease contract a clause such as the following:

> The party of the second part covenants and agrees not to do, suffer or permit to be done any act in violation of any provisions of any policy of insurance upon any of the crops, buildings, or other property upon said premises or which shall increase the premium thereon, and that he will not sell or allow to be sold thereon or therefrom any goods at auction.

TAXES.

The landlord usually assumes the responsibility for all real estate taxes, both in cash and share leases. Occasionally, however, the tenant agrees to work out the road tax. Taxes and insurance on operating equipment, live stock, and other property are usually paid by the owner of such capital, being shared when the property is jointly owned.

DESIGNATION OF PROPERTY TO BE USED BY TENANT.

Every farm lease, whether cash or share, should indicate clearly what property is to be used by the tenant and what is to be reserved from use. Generally it is easier to specify the property reserved from use. All the property not so specified will by implication be subject to use by the tenant under the contract of lease. The particular items of restriction may vary from farm to farm, as, for instance, in the amount of use the tenant may make of standing timber. The reservations may include such items as use of fruit, wood, standing timber, minerals (in the case of a long lease), fish and game, gravel beds, sand pits, certain rooms in the house, portions of outbuildings, etc.

In the case of farms or estates where it is the practice to rent principally the crop land to tenants it may be desirable to designate what use the tenant may make of land and buildings other than the crop land. Frequently the tenant is given free use of a residence, a garden spot, pasturage for a limited number of stock, and, where available, the privilege of obtaining firewood and fruit.

FARMING SPECIFICATIONS.

It is customary to include in farm leases a clause stipulating that the tenant shall " well and faithfully till and farm the premises above described in a good and farmerlike (or husbandmanlike) manner." Such a clause requires only that the tenant shall not violate the conventional standards of farming prevailing in the neighborhood, which may be good or bad, as the case may be.

It is usually desirable, both in cash and share leases, that more detailed specifications with respect to the method of farming be included. In the case of cash leases these specifications will take the form principally of provisions for safeguarding the fertility of the land. In share contracts the landlord is vitally interested in the annual production of the land and has a right to include such provisions as may be necessary to insure efficient farming. When the landlord finds it possible to devote considerable attention to supervision, and it has been agreed that he shall exercise this supervision, detailed farming specifications need not be included in the lease contract. In any case such restrictions should not unduly fetter the tenant so that he is handicapped in his efforts to operate the farm efficiently.

The list of farming specifications is sometimes made a distinct and separate part of the contract. In order to make its provisions clear it may be accompanied by a map of the farm, showing such things as the proposed field system, location of permanent pasture and woodland, perennial crops not to be plowed up, fields to which manure is to be applied each year, drainage ditches, fences, roads, and other essential considerations.

The details that may be specified are so numerous and vary so largely, according to the individual case, that it is impracticable to discuss them fully in this bulletin. For instance, in some localities farm practice may not give proper recognition to the fertility lost by the burning of straw stacks and corn stalks, and in such localities it may be well to designate that the straw shall be spread and the corn stalks rolled, disked, and plowed under. All leases should safeguard the fertility of the farm as far as possible by providing for the utilization by live stock on the farm of a reasonable proportion of the feedable crops and the return to the soil of the manure, straw, and other roughage. A landlord leasing land to a tenant who lives and keeps his live stock on another farm should, in particular, take precaution to secure the return of a part of the manure if the straw, corn stover, or other roughage is removed from the land rented. The lease should provide against trampling of fields by stock in the spring or in muddy weather, and prohibit overgrazing or the pasturing of unringed hogs or breachy cattle. It is especially important to provide that noxious weeds shall not be allowed to go to seed on the premises or on roads or lanes adjacent thereto.

In addition to these safeguards the lease may specify the field and rotation systems in detail. It may even be desirable to specify the method of plowing, as, for instance, where Mangum terraces must be maintained to prevent erosion. Sometimes it is desirable to specify such a thing as the method of thrashing, to prevent the spread of weed seeds, and to reduce waste of grain.

COMPENSATION FOR IMPROVEMENTS.

As pointed out above, assurance of compensation for unexhausted improvements is essential in a lease granted only for a short term of years if the tenant is to be expected to farm conservatively and in a way that will increase rather than decrease the fertility of the farm and the value of the improvements. Compensation for improvements has been required by law in England for many years. In the United States, however, it has not been extensively practiced, and consequently in this country we lack experience in determining values. England not only has statutes on the matter but she has well-developed agencies by which practice in determining compensation is improved and standardized.

Improvements concerning which problems of compensation may arise may be classified as follows, this classification being based on points covered by the English agricultural holding acts:

(1) Buildings, silos, fences, and other structures.

(2) Laying down of permanent pasture.

(3) Irrigation systems.

(4) Making or improvement of roads or bridges.

(5) Making or improvement of watercourses, ponds, wells, or reservoirs, or of works for the application of water power or for supply of water for agricultural or domestic purposes.

(6) Making or removal of permanent fences.

(7) Planting orchards or fruit bushes, and protecting them.

(8) Reclaiming waste land or building embankments and sluices against floods.

(9) Drainage of land.

(10) Application to the land of lime, marl, ground rock phosphate, or other fertilizers which will result in a residual benefit to the land after the termination of the lease.

(11) Consumption on the farm by live stock of feedstuffs not produced on the farm.

(12) Consumption on the farm by live stock of feedstuffs produced on the farm.

(13) Laying down temporary pasture with clover, grass, alfalfa, and other seeds, sown not more than two years prior to the termination of the lease contract.

(14) Plowing and preparation of land for seeding or seeding of crops which will be harvested after the termination of the lease contract.

In this country in special cases compensation may be needed in connection with the leveling of land for irrigation purposes and the terracing of land for the purpose of minimizing danger from soil erosion. Compensation may also be of importance in connection with land-improvement work, such as removing stone, stumps, brush, and weeds. Under the English law the various improvements numbered from 1 to 8 inclusive are subject to compulsory compensation only when the landlord has given his consent to the making of the improvement. For drainage improvements (number 9) the tenant must give notice to the landlord not less than two nor more than three months before the work is to begin. During this period the landlord may make the improvement himself, charging the tenant a reasonable rent for its use after completion. The improvements numbered 10 to 13 inclusive may be made by the tenant and are subject to compulsory compensation without giving notice to the landlord.

Number 14 is not contained in the English classification because it is presumed that it is provided for in the lease. As a matter of fact, there are two ways of making such provision. If plowing or seeding has been done by the preceding tenant, the new tenant may pay the reasonable cost for the work. At the termination of the lease the new tenant should be paid by the landlord or by the incoming tenant for similar work. Another method is for each tenant to leave as much plowed or seeded land as was taken over by him at the beginning of his tenancy. This method, however, is likely to be less satisfactory than the method first mentioned.

The problem of determining the amount of compensation to be allowed for improvements numbered from 1 to 9, inclusive, is not of unusual difficulty. The tenant should be allowed the reasonable cost of making the improvement less any depreciation on the improvement that occurs before the termination of the lease contract. Compensation for such improvement may be made at the time the improvement is completed, or may await the termination of the lease. Where the usefulness of an improvement is likely to end before the tenant leaves the farm the tenant should expect no compensation unless he leaves the farm before the usefulness of the improvement has ceased. In the case of durable improvements, on the other hand, usually the landlord should pay for the improvement when completed, and then add enough to the annual rent to cover the interest and depreciation. Where, as is often the case on share-rented farms, an improvement is of equal advantage to landlord and tenant the landlord should bear at least his proportionate share of the initial cost, compensating the tenant for his interest in any improvement remaining at the termination of their share relationship.

The compensation to be allowed for the residual value of manure and fertilizer applied to the farm land is a problem of considerable difficulty because of the lack of exact knowledge as to the actual quantity of fertility that is likely to remain in the soil under varying conditions. Frequently, the decision may be satisfactorily left to arbitration or to a disinterested third party. In the case of manure resulting from the feeding of crops which have been produced on the farm compensation should not be allowed when such a feeding policy is recognized as the usual practice of the community. Sometimes, however, it pays better to sell crops than to feed them. Where this is the case the tenant, in order to encourage him to feed rather than to sell, may be compensated either by a deduction from his rent or by compensation for the unexhausted value of the manure applied to the soil.

In the case of other fertilizers it has been suggested that the initial cost (excluding labor of application) shall be reduced for each year of use after application 25 per cent for ground limestone; 10 per cent for ground raw phosphates; and for soluble fertilizers such as steam bone meal, acid phoshates, and potash salts, 50 per cent the first year and 75 per cent the second year.[2] While the above percentages may not be regarded as correct for all conditions, they may be helpful to landlords and tenants in arranging terms for compensation.

PROVISIONS FOR ENFORCEMENT.

It is desirable to include in a lease clauses providing methods for enforcing the contract. Enforcement clauses may deal specifically with (a) the performance of farm work, the making of repairs and other duties assumed by the tenant; (b) gross damage to the property rented through neglect or wilful injury; (c) the making of repairs, the furnishing of capital, the supplying live stock and equipment, and other obligations assumed by the landlord; (d) the payment of rent. The first of these considerations is especially important for a share-rent contract.

A clause to enforce compensation for failure to perform agreements on the part of the tenant or for damage to the property of the lessor may read as follows:

> It is hereby agreed that in case the party of the second part shall fail to perform his agreements or any of them herein contained, then the party of the first part shall have a right to hire any person or persons he may see fit to perform the agreements of the second party and all expense incident thereto shall be charged to the party of the second part and taken out of his share or interest in the property owned in common. It is further agreed that in case of gross damage to the property herein leased through neglect or willful injury by the party of the second part, the party of the first part shall have a right to terminate the agreement and lease; but the exercise of such right to terminate the agreement shall not impair the right of the party of the first part to bring action to collect damages for such injuries.

In many States a lien is created by statute which provides that the landlord shall have first claim on the tenant's crops grown on the leased land for the payment of rent and advances made by him. As stated previously, in most of the Southern States the cropper is held to be a laborer and not a tenant. Consequently, ownership in the crop until after division is vested in the landlord. The payment of rent is often secured by a chattel mortgage on the tenant's crops or on live stock, machinery, and implements. Such a mortgage is sometimes embodied in the lease contract, but, like any other mortgage, should be executed with all the formalities required for a mortgage and should be recorded in order to give notice to third persons of the rights of the landlord under the mortgage.

A clause providing for enforcing the landlord's undertakings and obligations to the tenant may read as follows:

> It is hereby agreed that in case of failure of the said landlord to keep and perform any of the agreements hereinbefore mentioned or implied the said

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[2] From a bill to provide for compulsory compensation which was introduced in the legislature of the State of Illinois, but failed of passage.

tenant may perform the agreement, deducting the reasonable expense for such performance from such rent as may be or shall become due, and in case the agreement which the landlord fails to perform is of such character that it may not be performed by the tenant the contract shall, at the option of the said tenant or his assigns, be forfeited.

Provided, further, that nothing herein mentioned shall impair the right of the tenant to bring action for specific performance of the contract or for such damages as the said tenant may have suffered through failure of the landlord to perform the terms of the agreement.

It may be mutually agreed that any legal costs and expenses incurred by either party in enforcing the terms of the agreement shall be paid by the other party to the action. However, in several States this does not apply to attorneys' fees, and in any case the court will allow only such fees as are reasonable, irrespective of what may have been previously agreed upon.

ADJUSTMENT OF DIFFERENCES.

The above somewhat strict provisions for enforcing the terms of the contract should be regarded as safeguards to be applied only in last resort. Misunderstandings and litigation between landlord and tenant are likely to be very expensive to both parties. So far as possible, it is desirable to anticipate points of conflict and provide for them when the contract is made, for at that time both parties are anxious to agree. If both parties have the right spirit, any subsequent unforeseen difficulties can be adjusted by mutual agreement. However, there may be occasions when disputes arise which can not be so settled. Provision for adjusting such disputes may read as follows:

If the parties hereto are unable to agree upon any matter not definitely determined by this lease, each shall choose a referee, and they two shall choose a third, which three shall make a decision, and their decision shall be binding upon the parties hereto. None of said referees shall be related to either party or have any interest directly or indirectly, personally or otherwise, in the questions decided.

SOME SPECIAL PROBLEMS OF SHARE LEASES.

In an earlier part of this bulletin we have discussed some considerations common to all leases whether cash or share. In the share lease, however, the relation of the landlord to the farm is so much more intimate than in the case of the cash lease that a number of problems arise which are not encountered in cash leases.

RESTRICTIONS ON OUTSIDE WORK BY TENANT.

Since the rent of the landlord in the share lease vitally depends on the size of the crop the landlord needs some assurance that the tenant will not neglect the farm work in order to attend to outside interests. Therefore it is sometimes the practice to introduce into the lease a clause which specifies that the tenant shall not farm other land and that he shall not engage in other kinds of work that will distract his attention from the farm, such as engaging in the business of thrashing or baling hay for others. Sometimes it is not desirable to make such a clause too rigid. It may be that the tenant can economically help his neighbors thrash, bale hay, or put up silage, either in exchange for other labor or for cash payment. It may even be desirable for the tenant to farm other land if the original farm is not sufficiently large to engage all of his time. The restrictive clause should be drawn according to these special circumstances.

SAFEGUARDS WITH RESPECT TO JOINT EXPENDITURES AND SALES OF JOINTLY OWNED PROPERTY.

In stock share leases and other share contracts which approximate the character of economic partnership, each party is vitally interested in the wisdom and honesty with which expenditures and sales are made. It may be that the landlord has so great confidence in the tenant's honesty and discretion that he is willing to trust the tenant to transact all of this business. On the other hand, if the tenant is inexperienced in business matters, it may be to his interest, as well as to that of the landlord, that the latter make all purchases and sales for the joint account. Generally speaking, one party or the other should be designated for this purpose; for confusion is likely to arise where both are buying and selling without mutual consultation. The two parties to the contract should have a definite understanding with respect to this matter; otherwise, it may be a fertile source of disagreement.

Since there are numerous minor expenditures about which it is inconvenient for both parties to consult before acting, a clause reading as follows may be found satisfactory:

> Expenditures for the joint account or sale of jointly owned materials, live stock, and other farm property, if not exceeding in each case the sum of $25, shall be made by the lessee without consultation with the lessor. All expenditures for the joint account and all sales of jointly owned property in excess of $25 shall be made only on the mutual consent of both parties. It is further agreed that whenever an expenditure or sale is made on joint account the party making such expenditure or sale shall furnish the other party satisfactory vouchers or receipts.

Sometimes it is found desirable to require that all business for the joint account shall be transacted through a specified bank, e. g.:

> All joint business in the way of payments and receipts shall be transacted through the ——— Bank of ———.

When the joint interests of the two parties are greatly intermingled, as is likely to be the case in a share-lease contract which partakes of the character of an economic partnership, it is essential that careful records be kept of all transactions, and it is desirable to require in the contract itself the keeping of such records. The following is a clause providing for this purpose:

> The lessee shall keep a strict financial record of the farm business, which includes a careful inventory of the land, equipment, and personal property, excepting household goods, and a complete record of the purchases and sales on account of the farm business, excepting household and other personal expenses of the lessee.

RESERVATION OF RIGHT OF SUPERVISION BY LANDLORD.

In the case of many share contracts the tenant is a young man, who will benefit by the advice and supervision of the landlord; and, in order to avoid misunderstanding, it may be desirable to insert in the contract a clause which will provide for the exercise of such supervision. Such a clause may read as follows:

> The party of the second part shall consult the party of the first part, or his representative, about all matters pertaining to said farm, including the fields to be planted, the plowing, cultivation, harvesting, and the handling, disposition, and sale of the crops and other products and stock of said farm, abiding by the decision of the party of the first part or his representative.

AMOUNT OF RENT AND TIME AND METHOD OF PAYMENT.

Great care should be used in defining carefully the method of dividing the products of the farm. It should be clearly indicated whether the division is to be made before certain expenses are deducted or after such deduction. This is especially important in the case of those share leases which are approximately economic partnerships. It should also be carefully stated what use of undivided products may be made by each party. Often, for instance, the tenant is allowed milk, eggs, and other products for family use out of the joint product of the farm. In some instances, also, the landlord receives certain things for family use out of the undivided product. However, if it is desired to make an accurate and careful division, it is necessary to take account of all these minor items, and in this case the tenant or the landlord should be charged for all jointly owned products used by him. In any case the lease should make clear the rights of the respective parties in regard to these matters.

It is also frequently customary to allow the tenant to feed work stock from undivided grain or hay and sometimes to feed a few hogs in like manner. Very commonly the tenant is allowed to feed poultry out of the undivided grain. If these privileges are to be allowed, however, the contract should provide definitely the maximum number of each kind of stock that the tenant may keep in this manner. A more accurate method is to require each party to feed all private stock out of his share or to charge him for all feed used out of undivided property.

When the share lease applies only to crops, and not to live stock, it is frequently customary to charge the tenant cash rent for the use of pasture, since the landlord receives no benefit from this use. Sometimes a small amount of pasture may be allowed free as a special inducement to the tenant, or it may be balanced by some special advantage to the landlord in the division of the crops. However, when the lease applies both to stock and crops both parties benefit from the use of the pasture and no arrangement for pasture rent is necessary.

The time of division or payment of rent should be carefully indicated. On the great majority of farms the custom is to make the division or to pay the rent after the principal products of the farm have been harvested. In the case of dairy farms it is not infrequently customary for the landlord to receive his part of the milk check each month. However, when the lease is of the character of an economic partnership in which division is made only after expenses are deducted, it may be found difficult to divide the proceeds of the business so frequently.

It is also desirable to specify definitely where the landlord's share of the crop is to be delivered to him, as well as the method of making the division. Sometimes the division is made in the field, as in the case of corn, and some leases contain a provision that in order to facilitate division, corn is to be shocked in straight rows across the field with the same number of corn rows included in each shock row. Delivery is usually made in the crib or bin or at market. If it is desired that the tenant shall deliver the landlord's share at the shipping point this should be specified in the contract. This provision is frequently used as one of the balancing items in more or less complicated share leases. However, if the simplified type of lease hereafter suggested is employed, delivery of the landlord's share should be regarded as a part of the labor of the farm and should be included in the general estimate of the cost of labor, made preliminary to the determination of the shares of the respective parties.

Frequently the landlord trusts the tenant to make an honest division of the product. However, if the landlord is unwilling to do so he should specify that the division shall be made in the presence of himself or his representative.

FINAL DIVISION OF JOINTLY OWNED PROPERTY.

When live stock, crops, implements, feed, and other property are owned jointly, it is desirable to provide for an equitable method of dividing the jointly owned property in case of termination of the lease. Several practicable methods of making such division are employed, some of which are stated in the following clause from an Oklahoma lease:

> At the termination of this lease the jointly owned property may be disposed of in one of three ways: Such property may be appraised by disinterested parties selected by the parties of the first and second part, either party paying the other party one-half of the appraised value and retaining the entire property. If a division of the property is desired the tenant shall divide the jointly owned property into two lots and the landowner shall take his choice of the two lots. In case neither of these plans is agreed upon, then the property shall be sold at public auction and the proceeds equally divided. Nothing herein shall be construed, however, to prevent the disposal of the jointly owned property by any other plan mutually agreeable to both parties.

The general provision for arbitration of disputes suggested above should be applied to the division of property at the termination of the lease.

At the beginning of a lease, when either party is buying a share in property to be held in common, such as live stock, implements, or feed, it may be found difficult to agree on the price at which the share shall be taken over. In case of such disagreement, disinterested parties should be employed to appraise the property and thus settle the dispute.

FUNDAMENTAL PRINCIPLES UNDERLYING ALL LEASE CONTRACTS.

A great many difficulties in the making of satisfactory leases may be eliminated by proper appreciation of a few fundamental principles. The farm lease is essentially a contract in which the landlord sells to the tenant the restricted right to use a farm for a certain period of time. It is of great importance to determine as accurately as possible the correct value of this right of use. If the price charged is too high the tenant is likely to find the business of farming unprofitable, and will be unable to continue the arrangement and live up to it. It is of the highest importance both to landlord and tenant that the lease be so drawn as to result in stability of tenure, for frequent moves are not profitable to either party.

Frequently, landlords assume that they should have a rent for the farm equivalent to a certain rate of return on the value of the farm; that is, that the farm should yield at least 4 or 5 per cent, or some other rate of interest, on its value. In some regions this assumption may be a reasonable starting point in determining proper terms, but there are a number of conditions which tend to make such a method an improper basis of determining rental value. In the first place, in regions where land value has been rising rapidly it is found that farm land has been greatly overvalued in relation to its income because the increase in value itself is regarded as a part of the reward of land ownership. Consequently, men will pay much more for farm land that is rapidly increasing in selling value than they would pay if the rent itself were regarded as the only source of return. For instance, it has been found in the State of Iowa that where this condition prevails the average annual cash rental value of land is little more than 2 per cent of the average selling value of the farm. To charge a tenant 5 or 6 per cent on such value would be to handicap him seriously in the possibility of making a profit from his farming operations.

The overvaluation of land is sometimes due to the tendency of farmers to buy farm land for other than financial considerations. The farm is a home and one may pay a good deal for neighborhood advantages, for proximity to friends, relatives, church, and school, as well as for other residential advantages, including the farm house and other conveniences. Again, farmers have a certain pride of ownership which often will cause them to pay an unduly high price for a fine farm in the same spirit that one might pay an exorbitant price for a fine driving horse.

The landlord and tenant jointly make contributions to the business of production. Each should receive for his contributions what they are worth. If the total product of the farm, year after year, is not enough to pay the value of these contributions, the business must be regarded as unprofitable. As a matter of fact, however, the annual value of land may be considered a surplus above the other expenses of production. If some permanent change occurs to reduce the total average value of the product, in the long run the rental value of the land must fall because less will remain after paying the cost of securing the other factors of production. On the other hand, if a permanent change occurs to increase the average value of the product without increasing in the same proportion the other expenses, there will be a larger remainder that may be obtained by the landowner as rent.

The lease contract, especially in the case of the cash lease, tends to obscure this fact, for in the cash lease the tenant agrees to pay the landlord a fixed cash rent, and receives whatever may be left after paying this rent for his own expenses of production and profit. Landlords should bear in mind, however, that in the long run tenants must earn enough after paying rent to cover their expenses of production and a fair return for their own labor and risk. Moreover, a good tenant should receive more for his time than a poor tenant. In other words, if the return is such that an ordinary tenant can make fair wages, an enterprising and skillful tenant should receive a superior reward for his enterprise and skill. These principles, however, should not be interpreted to mean that a shiftless, indolent, and inefficient tenant should be guaranteed a living. (Such a man should not be in charge of a farm.)

PRINCIPLES UNDERLYING SHARE CONTRACTS.

In the share lease the landlord usually furnishes something more than merely the use of the land. In the simplest form of the share contract the landlord at least participates in the risk of the enterprise arising from variations in yields and in prices. In the more complex forms, such as the stock-share lease, the landlord may furnish half of the working capital or more, may bear half of the expenses, and may share in the management, so that he is actually a partner with the tenant in the enterprise.

This complexity in the relationship of landlord and tenant makes it much more difficult to determine the fair division of the product, especially when there is no system of accounting by which the relative value of the respective contributions of the two parties may be measured. The result has been that the actual systems of share leasing which have become customary in different parts of the country and in different types of farming are largely the product of a rough process of experiment. Different items are used to balance one another in a sort of rough and ready manner without the employment of any underlying and permanent principle of division. There is such a bewildering variety of privileges and obligations of uncertain money value that it may be practically impossible, even with a careful system of accounting, to determine the actual net shares of the respective parties. Such items as the twine bill, the thrashing bill, the furnishing of grass seed and horse feed, the fertilizer bills, hauling crops to market, and the use of pastures, are juggled back and forth in various combinations. The confusion is made greater by the yearly variation in the actual and relative value of the various factors of cost and by changes in crop acreages and farm practice.

It is important that this rough and ready method of adjustment, which was not seriously inaccurate in the pioneer days of our agriculture when the relative values involved were not nearly so large as at the present time and when fewer of our farmers were tenants, should give way to a simpler and more accurate method of bargaining under which it would be possible in advance for each party to balance with some degree of accuracy his prospective expenses and receipts. In formulating such a contract it is necessary to classify the contributions of the respective parties. We may recognize the following main groups:

(*a*) The use of real estate and expenses on account of real estate, including taxes, insurance on buildings, and repairs.

(*b*) Ordinary farm labor.

(*c*) Work stock.

(*d*) Special skilled labor hired on special occasions.

(*e*) Farm implements and operating equipment.

(*f*) Live stock other than work animals.

(*g*) Miscellaneous expenses.

The landlord, of course, provides the real estate, and generally pays the expenses on account of real estate. However, it is frequently customary for the tenant to furnish the unskilled labor necessary for making repairs on buildings and fences, and in the case of long leases he may even furnish the unskilled labor for making some improvements.

If the use of the real estate is a factor which the landlord is best in a position to contribute, the labor needed to work the farm can best be contributed by the tenant. Other factors of production may be owned by one or the other of the parties and a practicable plan of leasing worked out, but seldom is a rented farm to be found on which the landlord furnishes any large share of the labor used to operate it. On the ordinary family-sized farm the tenant who is a capable worker may need to hire practically no labor, especially if his children are old enough to help. If labor must be hired to assist in working the farm, the tenant should pay for it, as he is in the better position to control its cost and to get the most work for the money spent. His share of the returns should be so large that he will be amply rewarded for his willingness to do all he possibly can himself and for his ability to use labor effectively.

In regard to the work animals and equipment there is more diversity of practice than there is in the furnishing of land or labor. In some parts of the country, especially in the South, the very poor tenants may furnish only the labor, while the landlord furnishes the land, buildings, work animals, and equipment. On other southern farms, and usually in the North, the tenant farmer furnishes the labor to work the farm as well as the work animals and equipment. The one who furnishes the work animals and equipment usually contributes the feed, upkeep, and replacement costs associated with the use of these factors of production. However, on stock share farms the tenant, although contributing the work animals and equipment, generally has the right to feed these animals from the undivided feed and supplies, and not uncommonly the landlord owns a part or full interest in some of the equipment or in some of the horses.

The simplest kind of share contract would be one in which all expenses, including the value of the use of land, were shared in some definite proportion, as half and half, and all receipts were shared in the same proportion. This would be in the fullest sense an economic partnership. Since, however, it is customary and largely desirable that the landlord shall invariably furnish the use of real estate while the tenant shall furnish the farm labor and also usually the work stock and equipment, it is possible to make a simple and accurate adjustment as follows: First an estimate should be made of the fair value of the use of the land and of the value of ordinary farm labor, with additional estimates of the cost of horse some definite proportion, as half and half, and all receipts were shared in the same proportion. This would be in the fullest sense an economic partnership. Since, however, it is customary and largely desirable that the landlord shall invariably furnish the use of real estate while the tenant shall furnish the farm labor and also usually the work stock and equipment, it is possible to make a simple and accurate adjustment as follows: First an estimate should be made of the fair value of the use of the land and of the value of ordinary farm labor, with additional estimates of the cost of horse labor and the annual cost of the use of the equipment. The value of each of these items may be determined with a fair degree of accuracy in advance. The ratio of the two values should be determined, and all other expenses and receipts should be borne in the same proportion. Suppose, for instance, that it is found that the fair value of the use of the land for a year is $500, while the fair value of the farm labor, horse labor, and use of equipment is $1,000. The ratio of these quantities is 1 to 2. The landlord should then pay one-third of all other expenses and the tenant two-thirds of all other expenses. After these other expenses have been deducted from the total receipts the landlord should receive one-third of the remainder and the tenant two-thirds of the remainder. If the land and labor have been fairly valued, the effect of this arrangement will be to apportion the shares of the product in exact proportion to the value of the contributions of the respective parties and there will be no unknown items in the calculation.

It may be objected that this arrangement will not conform to the convenience of the two parties with respect to contributing to expenses. Thus the tenant may not have sufficient funds to bear the share of expenses allotted to him, or it may not be convenient for the landlord to furnish his designated share of expenses. It is clear, however, that the total expenses must be borne by one or both of the two parties in some proportion. Whichever party is lacking in the necessary funds to defray his share of the expense should borrow the necessary amount from the other party or from some other source of credit, paying interest on the loan until the end of the crop year, when the net receipts are divided and the loan may be repaid.

This method of simplifying the rental contract conforms in part to customary practice. In most parts of the country a customary share has developed which is supposed to represent roughly the proportionate value of the invariable contributions of the respective parties. For instance, in the Cotton Belt it is customary for the tenant when furnishing work stock to pay the landlord one-fourth of the cotton and one-third of the grain. In the newer wheat regions it is generally customary for the tenant to furnish work stock and implements and pay one-third of the grain. Where land is more valuable the tenant will pay one-half of the grain. These customary shares, however, do not take into account the variation in value between individual farms, and consequently other items of expense such as the twine bill, the threshing bill, the fertilizer bill, the furnishing of the seed grain, and the amount of rent for special privileges payable in cash are employed as balances, resulting in an unduly complicated contract.

The method of adjusting the share contract suggested above has been proposed by a number of students of the tenant contract. However, it has frequently been assumed that the proportion should always be half and half—that is, that the landlord should furnish the land and the tenant the labor, sharing other expenses equally and sharing equally in the net receipts. There is no reason, however, why the proportion should always be in this ratio. The values of the respective contributions vary greatly from section to section and from farm to farm. Thus, in the case of very intensive crops, such as sugar-beets, cotton, tobacco, and various truck crops, the value of labor in proportion to the value of land is likely to be greater than in the case of general farm crops. This difference is commonly reflected in ordinary share contracts by giving a greater share to the tenant. For instance, in the South the tenant pays the landlord one-third of the grain but only one-fourth of the cotton. Moreover, some farms are more valuable than other farms. The good farms, however, are likely to attract the more efficient tenants, and therefore the normal ratio of the value of land to the value of labor in the community may not be so greatly disturbed by this element. In other words, if the annual value of ordinary land in the community is one-half the value of the labor of the ordinary tenant, it is quite possible that the value of a farm of superior fertility, location, and equipment may be balanced against the superior efficiency of the tenant who may be secured for that farm.

These differences between the relative values of land and labor required in the production of different crops give rise to one objection to the system of share renting suggested above, an objection which is common to all share-renting systems which provide a uniform rent share for all farm enterprises. The uniform share may overvalue the labor applied to one enterprise as compared to that required for other enterprises. If this is true, the farmer may be tempted to devote more labor to the overvalued enterprise at the expense of those undervalued. Thus, when the equitable rent shares of corn and cotton considered separately are respectively one-third and one-fourth, a uniform share rent of two-sevenths would tend to overvalue labor employed on cotton and correspondingly to undervalue that employed on corn.

However, when the landlord participates actively in the management of the farm he may prevent any disproportionate use of labor that might result from a uniform-share contract.

In estimating the value of the annual use of land for the purpose of determining a fair division in the farm contract no deduction should be made for the annual expenses on account of the farm real estate, including expenditures for repairs, taxes, and insurance, for these expenses are in reality covered by the estimated annual value of the land.

protection to the respective parties, may only serve to call attention to points that may be made subjects of dispute.

At the outset each party should consider well not only the terms of the bargain but also the general desirability of the bargain itself.

The landlord should select his tenant with special regard to his personal qualities; of these honesty is of first importance, especially in the case of share renting. Good nature and tractability are of great importance. Experience and efficiency as a manager may not be so important from the landlord's standpoint in cash renting, and may be of less importance than such qualities as honesty, good nature, and energy, even in a share contract, provided the landlord is himself experienced and can devote considerable time to supervision. The landlord should also assure himself that the tenant can obtain the necessary equipment and capital to operate efficiently.

To obtain and hold a tenant having the desirable qualities the landlord can well afford to make numerous minor concessions in the contract. Indeed, a sharp bargain which proves a source of dissatisfaction and hard feeling on the part of a good tenant may prove a costly bargain for the landlord.

A landlord will usually find that the easiest way to get his tenant to do certain things is to make it profitable for the tenant to do them.

The tenant, in making a choice, needs to consider both the landlord and the farm. The importance of a good landlord is in direct proportion to the intimacy of the relationship imposed under the terms of the contract. In a cash lease the relationship may often be largely impersonal, whereas in a stock-share lease the relationship is so close as to make good feeling and the spirit of mutual cooperation and concession essentials of success.

The proper choice of a farm involves considerations so numerous that they cannot be fully elaborated in this bulletin. However, just as the landlord can afford to make some concessions in order to secure a good tenant, so the tenant should remember that the difference in productivity between a good and a poor farm may be so great as more than to compensate for a contract that may be illiberal in minor details.

In general the tenant should look well to the character and condition of the land, the presence or absence of noxious weeds, the character and condition of the dwelling house, barns, and other outbuildings, the fences, the character of the roads, the water supply, the pasture facilities, and supply of wood. The tenant may consult the outgoing tenant, the neighbors, his banker, the thresherman, and other persons in a position to give accurate information.[3]

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[3] See Farmers' Bulletin 1088, "Selecting a Farm."

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UNITED STATES
DEPARTMENT OF AGRICULTURE

Farmers' Bulletin 1164

The
FARM LEASE CONTRACT

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1939

AMERICAN TRAPPERS receive yearly in the aggregate many millions of dollars for their fur harvest, which, up to the moment they set out to gather it, does not cost them a single effort. Recently the supply of peltries has been decreasing at an alarming rate. Raw-fur buyers representing all parts of the country place the decrease at from 25 to 50 per cent during the last 10 years. There are no longer any virgin trapping grounds. Even in Alaska the two most important fur-bearing animals, the beaver and the marten, have become so nearly exterminated that they are now being protected by a close period.

Laws protecting fur-bearing animals are designed to keep a steady flow of peltries coming to market year after year, thereby bringing trappers a reliable income and giving regular employment to thousands of people engaged in dressing skins, manufacturing garments, and distributing them through the various avenues of trade.

A general protest comes from raw-fur buyers against traffic in unprime skins. The losses caused by killing fur animals when their pelts are not prime are enormous. An educational campaign is greatly needed to prevent this waste and to perpetuate our fur-producing resources.

It is hoped that the information contained in this bulletin will be instrumental in promoting judicious and harmonious action in this important matter.

Contribution from the Bureau of Biological Survey
E. W. NELSON, Chief
Washington, D. C. August, 1920

LAWS RELATING TO FUR-BEARING ANIMALS, 1920.[1]

A SUMMARY OF LAWS IN THE UNITED STATES, CANADA, AND NEWFOUNDLAND, RELATING TO TRAPPING, OPEN SEASONS, PROPAGATION, AND BOUNTIES.

GEORGE A. LAWYER, *Chief United States Game Warden;* FRANK L. EARNSHAW, *Assistant, Interstate Commerce in Game;* and NED DEARBORN, *Assistant Biologist.*

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LEGISLATION OF 1920.

LEGISLATION relating to fur-bearing animals in 1920 is small in volume. Only six of the eleven States holding regular sessions this year enacted laws on the subject, while changes in laws in eight Canadian Provinces related chiefly to royalties on skins and to prescribing licenses for trappers and fur dealers. Federal legislation comprised the provision in the appropriation act for the Department of Agriculture transferring jurisdiction over land fur-bearing animals in Alaska from the Secretary of Commerce to the Secretary of Agriculture, and the adoption of regulations thereunder effective July 1, 1920. No radical changes were made in the former regulations of the Secretary of Commerce except districting the Territory. The principal provisions of the new laws are set forth in the following brief summaries:

Federal.—One act: Transferring from the Secretary of Commerce to the Secretary of Agriculture jurisdiction over mink, marten, beaver, land otter, muskrat, fox, wolf, wolverine, weasel, and other land fur-bearing animals in Alaska, and the leasing of certain islands in Alaska for the propagation of fur animals; and transferring to the Secretary of Commerce jurisdiction heretofore exercised by the Secretary of Agriculture over walrus and sea lion (Agricultural appropriation act—Public, No. 234, 66th Cong.). Under date of June 12, the Secretary adopted regulations effective July 1, 1920, for the protection of land fur-bearing animals in Alaska. Under these, the Territory is divided into three districts: *District 1* includes the Aleutian Islands, Alaska Peninsula, and Southeastern Alaska, from Yakutat Bay to Dixon Entrance; *District 2*, the region north of Yakutat Bay to the headwaters of streams flowing into the Arctic Ocean, north of the sixty-eighth parallel of north latitude; *District 3*, the region drained by streams entering the Arctic Ocean north of the sixty-eighth parallel of north latitude. Other provisions are: Prohibiting the killing of any land fur-bearing animal when its fur is unprime; protecting beaver until 1923 and marten until

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[1] Laws relating to game animals, including deer and other big game, rabbits, and squirrels will be found in Farmers' Bulletin 1138, "Game Laws for 1920."

1925; fixing open seasons on muskrat, otter, mink, weasel, lynx, and fox, in the various districts; prohibiting the use of "klips" traps, steel bear traps, and any other trap with jaws having a spread exceeding 8 inches, and the use of dogs and poisons in taking or killing protected fur-bearing animals; prohibiting possession or shipment of skins of animals illegally killed; and requesting reports of shipments of furs consigned to points outside of Alaska (S. R. A.-B. S. 33).

Louisiana.—One act: Shortening the season on fur animals two weeks by closing the season with January 31 instead of February 15 (No. 136).

Maryland.—Four acts: Fixing a State-wide open season on otter and muskrat from January 1 to March 15, and prohibiting possession of green skins after March 25; prohibiting capture of otter or muskrat except by trapping or gigging, and protecting muskrat houses; authorizing payment to the informer of half the fine for violation of the act and the balance to the State game protection fund (S. B. 133); fixing bounties in Garrett County of $4 on wildcat, $2 on fox, and 50 cents each on mink, weasel, hawk, and owl (H. 21); repealing the provision of the Code of Public Local Laws fixing a bounty of $1 each on fox in Washington County (H. B. 66); defining muskrat, otter, mink, and all other protected animals as game, and requiring a hunting license to hunt or trap them (H. B. 193).

New Jersey.—One act: Permitting raccoons to be possessed during first 10 days of close season, but prohibiting their export, except under nonresident license (ch. 31).

New York.—Two acts: Shortening the season 20 days on muskrat in the northern counties of the Adirondack region by opening December 1 instead of November 10, and shortening the season 40 days in the rest of the State by prescribing an open season from December 1 to March 31 (ch. 552); repealing the special provision allowing raccoons to be taken in the Catskill Park in any manner, except with traps, from October 15 to March 15, thus making the season from November 10 to February 10 uniform throughout the State (ch. 469).

Rhode Island.—One act: Lengthening the season one month on raccoon, muskrat, and mink by opening October 1 instead of November 1; affording protection to otter, and fixing the open season as October 1 to February 1.

South Carolina.—One act: Making it unlawful to shoot or trap foxes, to dig them out of the ground, or to push or drag them out of a tree or log.

Alberta.—One act: Closing the season on muskrat south of the North Saskatchewan River, but providing that the lieutenant governor in council may open the season in such territory and under such conditions as he may deem advisable and make regulations for the granting of permits, including the fees to be charged therefor; extending the close term on beaver until December 31, 1925; prohibiting trapping on game or forest reserves except under permit and regulations of the lieutenant governor in council; prescribing a $5 taxidermist license; requiring dealers in furs and skins of protected animals to be licensed (fees, resident, branch office, and traveling agent, $5 each; nonresident, $100); prohibiting export of furs and skins on which royalties have not been paid, except that a resident hunter or trapper is not required to pay royalty on furs or skins of animals taken by himself unless it exceeds $10 in any one year (ch. 37).

British Columbia.—One act: Permitting resident farmer and member of family to trap muskrats on dyked lands only under permit of game conservation board; requiring shipments of fur animals to be marked to show contents, and names and addresses of the consignor and consignee, and prohibiting agents of common carriers from accepting shipments not properly marked; requiring fur traders (including their branch offices in Province) to obtain licenses (fees, resident, $25; nonresident or his agent $200), but permitting a resident trapper to sell furs of animals taken by him without a license; requiring fur traders to keep records of transactions and make sworn annual returns thereof, and to pay royalty on skins taken in Province in accordance with regulations (Bill No. 12).

Manitoba.—One act: Prohibiting the purchase of furs from a trapper not the holder of a proper license, the number of which must be recorded at the time of such purchase; requiring fur traders to secure licenses for each post or place of business maintained in the Province; reducing the fee for permits to export live mink, fisher, and marten, from $5 to $1 each, and on muskrat to $2 per dozen; providing for the payment of royalties on furs as prescribed by the lieutenant governor in council; requiring a license to dress or tan furs (fee, $10); providing for the issue of licenses to operate fur farms (fee, $5); and requiring semiannual reports of operation.

New Brunswick.—One act: Prohibiting the taking of fur animals by the use of poisons; shortening the season two weeks on muskrat; extending the close term on beaver and sable to December 31, 1923; limiting the taking of beaver under special permit from the minister of lands and mines to the period from November 1 to April 1, and increasing the fee from $4 to $8 for each beaver taken; repealing the bounty on wildcat; increasing the fee from $25 to $50 for a nonresident trapping license, and the fees for licenses to traffic in or tan skins of game or fur animals (resident, from $2 to $10; nonresident or resident alien, from $25 to $50); increasing penalties for violations; requiring trappers and fur dealers to obtain licenses, to file declarations showing name, address, and location of warehouses, shops, posts, or caches where skins are stored, and the place where skins will be shipped out of the Province, and to make monthly reports of operations, but exempting hunters and trappers who are British subjects domiciled and residing in the Province, who actually hunt, provided they sell such furs to persons domiciled in the Province; requiring payment of royalties as fixed by the lieutenant governor in council on skins taken in the Province.

Northwest Territories.—Two orders in council: Prohibiting trapping on Banks Island (P. C. 533); authorizing the Minister of the Interior to remit fees for trapping licenses to members of Royal Canadian Mounted Police and officers of Dominion Parks Branch when on duty in Northwest Territories (P. C. 611).

Nova Scotia.—One act: Requiring licensed fur dealers to make monthly reports of operations; increasing penalties for violations (Bill No. 150).

Saskatchewan.—One act: Shortening the season on muskrat and prescribing the months of March and April as the open season south of Township 53, and the month of November and from March 1 to May 14 as the open season north of Township 52, instead of November 1 to April 30 throughout the Province; prescribing a $2 resident trapping license and requiring licensees on or before May 31 to return license to chief game guardian and report number of each kind of fur animal taken (ch. 50).

Yukon.—Two acts: Affording protection to lynx, marten, mink, and otter from April 1 to November 15 and on muskrat from June 1 to December 1; prohibiting the use of poisons in taking fur animals; requiring nonresidents to obtain license (fee, $100) to trap fur animals; and prescribing licenses for fur buyers and dealers purchasing furs for sale or export—fees: nonresident, $150; resident, $25; mercantile establishment buying furs, $10 for each post or place of business other than head office (ch. 1); increasing tax rates or royalties on furs to be exported (ch. 6).

SUMMARY OF LAWS RELATING TO SEASONS, PROHIBITED METHODS, LICENSES, POSSESSION, SALE, SHIPMENT, EXPORT, MISCELLANEOUS PROVISIONS, PROPAGATION, AND BOUNTIES.

The arrangement of the various provisions of law relating to fur-bearing animals has been changed in the present bulletin from that formerly used in order that the information presented may be more readily available to the reader.

In many States legislation for the protection of fur animals has not progressed to the stage of stringent regulation, and this condition, together with the peculiar commercial nature of the fur industry, makes it often exceedingly difficult to determine what restrictions, if any, apply to the transportation and marketing of furs.

In stating the open seasons, the plan of the New York law has been followed, as in the bulletin on the game laws for 1920,[2] to include *the first and the last days thereof.* Statements regarding trapping on lands of another do not take into consideration the general trespass laws of the State. The bounty laws included relate to all animals and birds on which bounty is paid.

FEDERAL LAWS.

Two Federal laws have a bearing on the fur industry of the United States—the Lacey Act, governing interstate commerce in wild animals, and the tariff act of October 3, 1913.

That part of the Lacey Act codified as section 242 of the Criminal Code (35 Stat., 1137) makes it unlawful to ship or transport "from any State, Territory, or District of the United States to any other State, Territory, or District thereof" the bodies or parts of bodies of any wild animal or bird killed or shipped in violation of the law of the State, Territory, or District in which the same were killed or from which they were shipped.

The tariff act of 1913 places a duty of 10 per cent ad valorem on live animals shipped into the United States. Paragraph 397 of this act places on the free list animals imported for breeding purposes by a citizen of the United States: "*Provided,* That no such animal shall be admitted free unless pure bred of a recognized breed and duly registered in a book of record recognized by the Secretary of Agriculture for that breed." This act has made it impossible thus far to admit free of duty any foxes or other Canadian fur animals for propagation. Raw furs not advanced in manufacture, are admitted free of duty.

LAWS OF STATES.

ALABAMA.

Open seasons:[3]	*Dates inclusive.*
Beaver, otter, bear, raccoon, opossum,[4] mink, muskrat	Nov. 1-Mar. 1.

Prohibited methods: No restrictions.

Licenses: Fee, $10; issued by probate judges. Landowners or landlords, tenants, and members of families may trap on own land during open season without license. Written permission required to trap on land of another.

Possession and sale: Possession of opossum and the young of protected fur animals prohibited during close season. No other restrictions.

Shipment and export: No restrictions.

Propagation: No legislation.

Bounties: None paid.

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[2] Farmers Bulletin 1138, "Game Laws for 1920."

[3] *Alabama:* Owner may protect premises in any manner at any time from depredations of fur animals.

[4] Opossums may be hunted with dog or gun: Oct. 15-Mar. 1.

ALASKA.[5]

Open seasons:[6]

	Dates inclusive.
District 1.[7]	
Muskrat	Dec. 1-Mar. 31.
Land otter, mink, weasel (ermine)	Dec. 16-Mar. 15.
Lynx, fox	Dec. 1-Jan. 31.
District 2.[8]	
Muskrat	Dec. 1-May 31.
Land otter, mink, weasel (ermine)	Nov. 16-Mar. 31.
Lynx, fox	Nov. 16-Feb. 28.
District 3.[9]	
Muskrat	Dec. 1-May 31.
Land otter, mink, weasel (ermine)	Nov. 1-Mar. 31.
Lynx, fox	Nov. 16-Apr. 15.
Throughout Territory.	
Beaver, marten, sea otter	No open season.[10]
Bear (black, glacier, and cinnamon), wolf, wolverine, squirrel, marmot, varying hare (rabbit), and Arctic hare	Unprotected.

Prohibited methods: Unlawful to take or kill fur animals with poison or by use of trap or device known as the "klips," steel bear trap, or any other trap with jaws having a spread exceeding 8 inches. The use of dogs for pursuing and killing protected fur animals and the use of poison for killing any land fur animal prohibited.

Licenses: None required.

Possession and sale: No restrictions on prime skins legally taken.

Shipment and export: No restrictions on prime skins legally taken. Shipments of furs consigned to points outside of Alaska should be reported to the Bureau of Biological Survey, Department of Agriculture, Washington, D. C.[11]

Propagation: No restrictions except on the Aleutian Islands Reservation, where permits to propagate fur animals and to trap them for breeding purposes must be obtained from the Department of Agriculture.

Bounties: Wolf, $15; eagle, 50 cents.

ARIZONA.

Open seasons:

Beaver	No open season.[12]
All other fur and predatory animals	Unprotected.[13]

Prohibited methods: No restrictions.

Licenses: Fee, $2.50; issued by warden, designated deputies, and clerks of boards of supervisors. License not required for trapping on own land, nor by persons under 18 years of age. Unlawful to disturb or remove the traps of licensed trappers on the public domain or on lands where they have permission to trap.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Miscellaneous: Unlawful to use fish or the flesh of any game bird or animal for trap bait.

Propagation: Under permit from State game warden, fur-bearing and predatory animals may be kept for propagation, exhibition, or sale.

Bounties: None paid.

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[5] *Alaska:* Regulations relating to land fur animals may be obtained upon application to the Secretary of Agriculture, Washington, D. C. For special information regarding sea otters and fur-seal fisheries and the Afognak Reservation, which are subject to special legislative and administrative control, application should be made to the Commissioner of Fisheries, Washington, D. C.

[6] Unlawful to kill any land fur animal when its fur is unprime.

[7] *District 1* includes the Aleutian Islands, Alaska Peninsula and neighboring islands, and Southeastern Alaska, mainland and islands, from Yakutat Bay to Dixon Entrance.

[8] *District 2* includes the mainland and islands from Yakutat Bay, Gulf of Alaska, Iliamna Lake, and Bristol Bay, northward to the headwaters of the streams flowing into the Arctic Ocean north of the sixty-eighth parallel of north latitude.

[9] *District 3* includes the region drained by the streams entering the Arctic Ocean north of the sixty-eighth parallel of north latitude.

[10] Season on beaver expires Nov. 15, 1923, and on marten and sea otter Nov. 15, 1925.

[11] Blanks for reporting shipments by mail may be obtained from postmasters and those for reporting other shipments will be supplied upon application to the Biological Survey, Washington, D. C., or to local fur wardens in Alaska.

[12] *Arizona:* Expires Dec. 31, 1922.

[13] Mountain lion, wolf, fox, coyote, lynx, wildcat, skunk, or other obnoxious animals may be taken on State game preserves only under regulations of the State game warden. Owner may protect his premises from the depredations of predatory and fur animals at any time.

ARKANSAS.

Open seasons:[14]	*Dates inclusive.*
Bear	Nov. 10–Jan. 15.
Beaver, otter	No open season.[15]
All other fur animals	Oct. 1–Mar. 1.

Prohibited methods: Unlawful to trap bears, or to hunt them at night with torch or searchlights.

Bag limits: One bear a season.

Licenses: Trapping license, $20 (only required for use of 12 or more traps). Hunting license required to kill bears: Resident, $1.10; nonresident, $15; dog, used in hunting bears, $1.50.

Possession and sale: Sale of raw skins is prohibited except between October 1 and March 15. Sale or exchange of bears prohibited.

Shipment and export: No restrictions except on bears, the export of which is prohibited except by nonresident licensee under affidavit that the bear was legally taken and is not for sale.

Propagation: The game and fish commission is authorized to issue permits to breeders of game and fur animals under such regulations as it may prescribe.

Bounties: County courts may offer bounty on wolf, wildcat, or panther, and fix the amount of such bounty.

CALIFORNIA.

Open seasons:[16]	*Dates inclusive.*
Black or brown bear, ring-tail cat, coon, pine marten, fisher, wolverine, mink, skunk, river otter, fox	Oct. 15–Feb. 28.
Seal and sea lion (in Game District 19, no open season)	Unprotected.
Beaver, otter	No open season.

Prohibited methods: Unlawful to use poisons or gun larger than No. 10 gauge in taking fur animals, or to dig, or smoke out skunks from dens.

Licenses:[16] Citizen, $1; alien, $2; issued by Fish and Game Commission. License issued free to veterans of Civil War. Duplicate license issued only on affidavit of applicant that original license has been lost or destroyed. License not required of person under 18 years of age. Licensed trappers are required to report catch before July 1. Licensee must exhibit license and furs to wardens or peace officers upon demand. Unlawful to disturb or remove the traps of a licensed trapper who is trapping on the public domain or on lands where he has permission to trap.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: Fur animals may be raised in captivity under regulations of the commissioners.

Bounties: Mountain lion, female, $30; male, $20; paid by State game commission. Boards of supervisors of counties may fix the rate and pay bounty on coyote, wildcat, fox, lynx, bear, or mountain lion. Many counties now pay a bounty on some of these animals, especially on coyotes.[17]

COLORADO.

Open seasons:[18]	
Beaver	No open season.[15]
All other fur animals	Unprotected.[19]

Prohibited methods: No restrictions.

Licenses: Hunting license required to trap: Resident, $2; nonresident, $25; issued by commissioner, county clerks, and other agents. Unnaturalized resident not permitted to hunt, capture, or kill any wild bird or animal.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Miscellaneous: Use of game or fish for trap bait prohibited.

Propagation: No restrictions, except as to beaver and game animals.

Bounties: None paid by State since 1895. On petition of 50 freeholders, county commissioners may levy a tax to pay bounties on coyote, wolf, and mountain lion.

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[14] *Arkansas:* Fur animals found destroying crops or poultry may be killed at any time.

[15] Expires Jan. 1, 1922.

[16] *California:* Written permission from board of fish and game commissioners required to trap or hunt predatory animals on State game refuges.

[17] For information in regard to bounties in any county, application should be made to the county clerk.

[18] *Colorado:* The owner of property being damaged by beaver may be permitted to kill them under such regulations as may be provided concerning disposition of the skins, by the State game and fish commissioner.

[19] A permit from the State game and fish commissioner is necessary to take mountain lion, wolf, coyote, fox, lynx, wildcat, mink, marten, or wolverine on Colorado State Game Refuge.

CONNECTICUT.

Open seasons: [20]	*Dates inclusive.*
Otter	Nov. 1-Mar. 31.
Raccoon	Oct. 16-Jan. 31.
Skunk	Nov. 1-Jan. 31.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to trap with scented baits or to take animals with a snare or similar device. Traps must be visited at least once in 48 hours, and, on lands of another, must not be set in path, wood road, or specially prepared furrow. Owner or person using traps must have his name legibly stamped thereon.

Licenses: Hunting license required to trap: Resident, $1.25; nonresident, $10.25; alien, $15.25; issued by city or borough clerk. Person under 16 years of age, while denied a hunting license, may obtain one for taking fur animals only. License not required of resident hunting or trapping on own land during open season. Permission of owner required to trap on lands of another.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: No restrictions on possession or sale of fur animals kept in captivity.

Bounties: Towns are permitted to pay bounty on wildcat or fox (not over $5); on weasel, woodchuck, wild Belgian hare, or wild German rabbit (not over $1).

DELAWARE.

Open seasons: [21]	*Dates inclusive.*
Skunk, mink, otter	Dec. 1-Mar. 25.
Fox	Oct. 1-Apr. 30.
Raccoon, opossum	Oct. 1-Jan. 1.
Muskrat	Dec. 1-Mar. 10.

Prohibited methods: Unlawful to use pitfall, deadfall, scaffold, cage, snare, trap, net, pen, baited hook, or baited field or any other similar device, or any drug, poison, chemical, or explosive for taking animals protected by the laws of this State, except muskrat, skunk, mink, and otter. Traps or other devices unlawfully set are subject to confiscation. Unlawful to destroy the nest, den, or lair of any animal protected by law. Unlawful to hunt, kill, take, or destroy any protected animal, except muskrat, skunk, mink, and otter, while the ground is covered with snow. Unlawful to shoot at or destroy any fox while it is being chased by a dog. Muskrats may not be taken during the time any flood or freshet may cause them to leave their usual places of shelter and protection, nor may they be shot at night or hunted with a dog.

Licenses: License not required of resident; hunting license required of nonresident (fee, $10.50); issued by commission.

Possession and sale: Unlawful to sell fox or fox hide. No other restrictions.

Shipment and export: Unlawful to export fox or fox hide. No other restrictions.

Propagation: No restrictions, provided a permit is obtained from the chief game and fish warden (fee, $1). A limited number of wild fur or game animals for propagating purposes may be taken under permit.

Bounties: None paid.

DISTRICT OF COLUMBIA.

No legislation relating to fur animals.

FLORIDA.

Open seasons:	*Dates inclusive.*
Beaver, otter	Nov. 1-Jan. 31.
Other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: No legislation.

Bounties: None paid.

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[20] *Connecticut:* Fox, skunk, raccoon, wildcat, mink, or weasel may be hunted or trapped on State game preserves only by superintendent of fisheries and game or persons designated by him. Landowner may kill otter at any time on his own land when damaging his property, and raccoon and skunk may be killed at any time for protection of property.

[21] *Delaware:* Owners may kill foxes at any time when destroying their poultry, and other fur animals may be killed at any time when destroying property.

GEORGIA.

(1920 laws not received.)

Open seasons:	*Dates inclusive.*
Opossum	Oct. 1–Feb. 28.
Fox (see exceptions)	Unprotected.
Exceptions: In Habersham County	Sept. 1–May 14.
In Elbert, Madison, and Oglethorpe Counties	Sept. 1–Feb. 1.
Other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: Hunting license required to trap: Resident, State license, $3; county license, $1; nonresident, State license, $15; issued by commissioner or county warden. License not required to trap in militia district or on own or leased land during open season. Permission of owner required to trap on lands of another.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: No restrictions on propagation of unprotected fur animals.

Bounties: None paid.

HAWAII.

Hawaii has no wild animals valuable for fur. There are no restrictions on the propagation of fur animals, except that mongooses and rabbits may not be kept or bred. Pet rabbits may be raised, if kept in confinement.

IDAHO.

Open seasons:[22]	*Dates inclusive.*
Otter, marten, mink, muskrat,[23] raccoon, fox, fisher	Oct. 1–Mar. 31.[24]
Bear, mountain lion, wolf, coyote, lynx, bobcat, jack rabbit, skunk, weasel	Unprotected.[24]
Beaver	No open season.[25]

Prohibited methods: No restrictions.

Licenses: Resident, $5; nonresident, $25; alien, $50; issued by warden, deputy, or authorized agent. No license required of resident women, veterans of Civil War, or of children under 12 years of age. Licensed trapper must make verified report at end of season of number and kind of fur caught, where sold, and the price received. Unlawful to destroy, disturb, or remove traps of licensed trapper.

Possession and sale:[25] Skins of animals legally taken, within or without State, may be possessed or sold at any time.

Shipment and export: No restrictions.

Miscellaneous: Unlawful to use flesh of any game animal for trap bait.

Propagation: Permit from State warden required. Permittee must make verified yearly report showing number of animals kept in captivity, number sold, and number on hand.

Bounties: Coyote, lynx, or wildcat, $2.50 each; bear or wolf, $20; mountain lion, $50; paid from predatory wild animal fund. Bounty of 2 cents each on pocket gopher, ground squirrel, and prairie dog; administered through the State live-stock sanitary board of the State Department of Agriculture.

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[22] *Idaho:* Person may protect own premises from depredations of fur animals, under permit from State warden.

[23] Muskrats may be destroyed in irrigated districts, but muskrat houses may not be disturbed except under permit of State warden.

[24] In Black Lake Game Preserve beaver, otter, marten, fisher, fox, mink, and wolverine are protected at all times; mountain lion, bear, lynx, wolf, coyote, and wildcat may be destroyed only by game wardens or duly authorized persons.

In Payette Game Preserve bear, lynx, wolverine, fox, otter, beaver, marten, mink, and fisher are protected at all times; mountain lion, timber wolf, coyote, and wildcat may be killed only by game wardens or duly authorized persons.

In Selway and Big Lost River Game Preserves beaver, otter, marten, fisher, fox, and mink are protected at all times; mountain lion, bear, lynx, wolf, coyote, wolverine, and wildcat may be killed only by game wardens or duly authorized persons. In Big Lost River Preserve badger, weasel, skunk, and rabbit may be killed by any one without permit.

In Big Creek Game Preserve beaver, otter, marten, fisher, fox, and mink are protected at all times; mountain lion, lynx, timber wolf, coyote, and wildcat may be killed only by game wardens or duly authorized persons.

[25] State warden may grant permits to take beaver when doing damage to irrigation canals, crops, etc. Pelts of animals taken must be turned over to warden for sale, half the proceeds going to the trapper. Possession of beaver hides otherwise prohibited.

ILLINOIS.

Open seasons:[26]	*Dates inclusive.*
Raccoon, mink, muskrat, skunk, opossum, fox, otter	Nov. 1–Mar. 15.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to use spear or similar device for hunting or taking fur-bearing animals, or explosives, chemicals, or mechanical devices or smokers of any kind to drive them out of their burrows, dens, or houses. Use of automobile or vehicle propelled by mechanical power, or the lights thereof, or ferret in hunting or taking fur-bearing animal prohibited.

Licenses: Resident, $1; nonresident, $10.50; issued by county, city, or village clerk. License not required of landowners and tenants and members of families to trap during open season on the lands on which they reside. License not issued to person under 16 years of age without written consent of parent or guardian; nor to alien. Licensee, on or before April 15, must report all hides of fur animals taken, sold, shipped, or dealt in, together with names and addresses of persons to whom sold or shipped. Permission from owner, agent, or occupant required to trap on land of another.

Possession and sale: Possession of green hides prohibited except from November 1 to March 25. No other restrictions on possession and sale.

Shipment and export: No restrictions on skins legally taken and possessed.

Propagation: Permit required to conduct a fur farm on which protected animals are reared; fee, $2.

Bounties: None paid by State; counties may pay bounty on groundhog and crow.

INDIANA.

Open seasons:[27]	*Dates inclusive.*
Beaver, raccoon, fox, otter, opossum, skunk	Nov. 20–Feb. 2.
Mink, muskrat	Nov. 1–Mar. 31.
Other fur animals	Unprotected.

Prohibited methods: Traps set on land of another must be placed at least 18 inches within burrow or hollow log and must be visited at least once in each 36 hours. Muskrat houses protected except when obstructing ditches or watercourses.

Licenses: None required of residents; nonresident, $15.50; issued by clerk circuit court. Written consent of owner, occupant, or lessee required to trap on land of another.

Possession and sale: Possession of fur animals or green hides prohibited during close season. No other restrictions.

Shipment and export: No restrictions on skins legally taken and possessed.

Propagation: All animals raised in captivity are considered domestic stock, and the owner may possess, sell, ship, transport, or otherwise dispose of them without regard to laws regulating the killing and disposition of wild animals. An inspection certificate, fee $10, must be obtained from the Department of Conservation.

Bounties: Boards of county commissioners may pay bounty on wolf, fox, woodchuck, crow, owl, or hawk.

IOWA.

Open seasons:	*Dates inclusive.*
Beaver, mink, otter, muskrat	Nov. 15–Mar. 15.[28]
Other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: Hunting license required to trap: Resident, $1; nonresident, $10.50; issued by county auditor. License not issued to person under 18 years of age without written consent of parent or guardian. Owners of farm lands, their children, and tenants may trap on own land without license during open season. Permission of owner, occupant, or agent required to hunt fur animals with dog or gun on cultivated or inclosed land of another.

Possession and sale: Possession and sale of beaver, mink, otter, and muskrat prohibited except during open season and first 5 days of close season.

Shipment and export: Export of protected fur animals prohibited.

Propagation: No restrictions except as to possession of protected species.

Bounties: Adult wolf, $10; wolf cub, $1; paid by county. Boards of supervisors of counties may allow bounty on crow, groundhog, pocket gopher, or rattlesnake.

KANSAS.

Open seasons:	*Dates inclusive.*
Muskrat, skunk, mink, raccoon, opossum, civet cat	Nov. 16–Mar. 14.[29]
Beaver, otter	No open season.[30]
Other fur animals	Unprotected.

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[26] *Illinois:* Houses and dens of fur-bearing animals protected except when obstructing public or private ditches or watercourses.

[27] *Indiana:* Protected fur animals may be killed at any time on one's own premises to protect property.

[28] *Iowa:* Fur animals may be destroyed at any time to protect public or private property.

[29] *Kansas:* Owner or legal occupant of land may destroy these animals at any time when they are destroying poultry or damaging other property.

[30] Expires in 1921.

Prohibited methods: No restrictions.

Licenses: None required. Written consent of owner or lessee required to hunt or kill wild animals on land of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation.

Bounties: Coyote, $1; wolf, $5; crow and pocket gopher, 5 cents each; paid by county.

KENTUCKY.

Open seasons:[31]	*Dates inclusive.*
Beaver, mink, raccoon, fox, otter, opossum, skunk	Nov. 15–Dec. 31.[32]
Other fur animals	Unprotected.

Prohibited methods: Traps must be set 18 inches or more within a hole, cave, or hollow log, and must be visited within each 36 hours.

Licenses: None required. Written consent of owner or lessee required to trap on lands of another.

Possession and sale: Possession of green skins during close season prima facie evidence of unlawful taking.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation.

Bounties: None paid.

LOUISIANA.

Open seasons:	*Dates inclusive.*
Bear[33]	Nov. 1–Feb. 15.
Muskrat, mink, otter, raccoon, skunk, fox, opossum	Nov. 1–Jan. 31.[34]
Beaver	No open season.
Wolf, fox, wildcat, cougar	Unprotected.[35]

Prohibited methods: Unlawful to trap bear. No other restrictions.

Licenses:[35] Resident, $2; nonresident,[33] $15. Issued by tax collector.

Possession and sale: Sale of skins prohibited during close season, but skins legally taken may be possessed at any time.

Shipment and export: All shipments must bear tags furnished by commissioner. Export of beaver taken in State prohibited; also of bear, except under written permission of the commissioner. No other restrictions on skins legally taken or possessed.

Miscellaneous: Use of birds for trap bait prohibited.

Propagation: Fur animals for breeding purposes may not be captured except under restrictions specified in permits issued by Department of Conservation. Permit from the department is required to import wild quadrupeds into the State or to export them from the State.

Bounties: None paid.

MAINE.

Open seasons:[36]	*Dates inclusive.*
Muskrat	Oct. 15–May 14.[37]
Raccoon	Aug. 15–Feb. 28.
Beaver	No open season.[38]
Bear, bobcat, Canada lynx (loup cervier), weasel	Unprotected.
Other fur animals	Oct. 15–Feb. 28.[37]

Prohibited methods: Unlawful to use snare, swivel, pivot, or set gun, or to put out poison for any animals. Traps may not be set within 25 feet of a muskrat house. Unlawful to dig out a fox den. Owner's name and address must either be plainly stamped on the trap or on a metal tag firmly attached to it. A bear trap must be inclosed in a "hut."

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[31] *Kentucky:* Fur animals may be killed at any time on one's own premises to protect property.

[32] Raccoon, opossum, skunk, and mink may also be taken with gun or dog from Oct. 1 to Feb. 15.

[33] *Louisiana:* Bears may be killed at any time on one's own land when actually damaging property. Nonresidents coming into State to hunt bears required to report in writing to Department of Conservation on or before arrival at destination.

[34] Muskrats may be killed at any time when damaging any levee, and, under permit of Department of Conservation, to prevent damage to cultivated or pasture land; any fur animal may be killed by the owner of land upon which it is destroying property.

[35] Wolves, foxes, and wildcats hunted for sport may be taken in any manner at any time, and may be possessed by the lawful holder of a State hunting license.

[36] *Maine:* Any person may lawfully kill any wild animal, except beaver, found destroying his property.

[37] Special laws on muskrat, otter, fisher, and mink in certain localities in Oxford and Washington Counties. For information apply to Commissioner of Inland Fisheries and Game, Augusta.

[38] Commissioner of inland fisheries and game, upon written complaint of landowner that beavers are doing substantial damage to his property, may declare special local open season on them (*see* "Licenses").

Licenses: Required to trap fur animals (except bear and bobcat) in unorganized townships: fee, $10; issued by commissioner. Licensee, on or before December 15 of each year, must make such report as the commissioner may require. Written consent of the owner or occupant must be obtained before setting traps on the lands of another in an organized county or incorporated place; such traps must be visited at least once in every 24 hours and any animals caught removed.

Special beaver-trapping license, good only in territory opened to beaver trapping by commissioner, fee, $25. Dealer in skins must be licensed (fee, State, $25; county, $2), and must keep a record of transactions and forward same to the commissioner of inland fisheries and game on or before December 20 of each year.

Possession and sale: Sale of beaver skins without seal of commissioner attached prohibited. No other restrictions on skins legally taken.

Shipment and export: Transportation of beaver skins without seal of commissioner attached prohibited. No other restrictions on skins legally taken.

Propagation: Permit required to raise fur animals (fee, $2). Protected species may be taken under special permits by licensed trappers for breeding purposes. No animals may be imported into the State without permit.

Bounties: Bobcat and Canada lynx (loup cervier), $10 each; paid by State; claim to be made within five days after killing or return from trip on which killing was done. Bear, $5; paid by State; claim to be made within 10 days after killing.

MARYLAND.

Open seasons:	*Dates inclusive.*
Otter, muskrat	Jan. 1–Mar. 15.
Other fur animals (except locally, as follows)	Unprotected.
Raccoon:	
In Allegany County	Sept. 1–Mar. 31.
In Anne Arundel and Prince Georges Counties	Oct. 1–Jan. 31.[39]
In Baltimore County	Oct. 1–Feb. 28.[40]
In Caroline County	Sept. 15–Mar. 31.
In Dorchester County	Nov. 10–Mar. 15.
In Harford County	Oct. 2–Nov. 30.
In Kent, Queen Anne, Somerset, and Wicomico Counties	Jan. 1–Mar. 31.
In Montgomery County	Oct. 15–Jan. 14.
Opossum:	
In Allegany County	Sept. 1–Mar. 31.
In Baltimore County	Oct. 1–Feb. 28.[40]
In Montgomery County	Oct. 15–Jan. 14.
In Washington County	Dec. 1–Mar. 31.
Mink:	
In Washington County	Dec. 1–Mar. 31.
In Worcester County	Dec. 15–Mar. 1.[41]
Skunk:	
In Washington County	Dec. 1–Mar. 31.
Fox:	
In Caroline County	No open season.[42]
In Carroll County	No open season.[42]
In Worcester County (chase with dogs)	Sept. 1–Mar. 9.
All fur animals (except as above mentioned):	
In Frederick County	Nov. 15–Feb. 28.[43]
In Harford County (trapping)	Nov. 15–Dec. 24.

Prohibited methods: Unlawful to take or kill otter or muskrat in any manner, except by gigging or trapping; to dig for muskrat or in any manner molest or destroy any part of a muskrat house or den. County restrictions as follows:

Anne Arundel County.—Unlawful to cut down tree to obtain a raccoon.

Baltimore County.—Unlawful to hunt raccoon or opossum on Sunday or when snow covers the ground.

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[39] *Maryland: Anne Arundel and Prince Georges Counties.*—Raccoon may not be taken between sunrise and sunset.

[40] *Baltimore County.*—Unlawful to set traps, except from Nov. 10 to Dec. 20, for mink, weasel, skunk, raccoon, opossum, or fox. Permits to take certain predatory fur animals when destroying property may be obtained.

[41] *Worcester County.*—Unlawful to take mink on land of another without permission of owner.

[42] *Caroline and Carroll Counties.*—Unlawful to kill a fox except by hounds in a hunt or when the fox is destroying poultry.

[43] *Frederick County.*—Raccoons or opossums may be hunted with dogs at night at any time. Land owners may protect property from ravages of fur animals.

Licenses: Hunting license required to trap: Resident, State, $5.10; county, $1.10; nonresident, $10.25 (fee $5.25 for State license if applicant owns real estate in Maryland assessed at $500; $1.25 for county license in county where such real estate is located); issued by clerk of circuit court—in Baltimore City by clerk of court of common pleas. License not issued to person under 14 years of age without written request of parent or guardian. Owners, tenants, and their children may hunt on own land during open season without license.

Possession and sale: Possession of green hides of otter or muskrat prohibited except from January 1 to March 25. No other restrictions on possession and sale of skins legally taken. County restrictions as follows:

Allegany and Baltimore Counties.—Possession of raccoon and opossum prohibited during close season.

Anne Arundel and Prince Georges Counties.—Possession of raccoon during close season prohibited.

Harford County.—Sale of raccoon for export from county prohibited.

Shipment and export: No restrictions on skins legally taken and possessed, except that raccoons may not be removed from Harford County.

Propagation: No legislation.

Bounties: A State bounty of 50 cents each on bird hawk, or chicken hawk, killed in State, paid from State game protection fund. *Garrett County:* Wildcat, $4; fox, $2; mink, weasel, hawk, or owl, 50 cents each; paid by county treasurer.

MASSACHUSETTS.

Open seasons:[44]	*Dates inclusive.*
Mink, otter, skunk, raccoon (see exception)	Nov. 1–Mar. 1.
Exception: Raccoon may also be hunted with dog and gun during October.	
Muskrat	Nov. 1–Apr. 30.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to open, disturb, or destroy muskrat house or to set trap within 10 feet thereof. Traps must be marked legibly with owner's name and must be removed at end of open season. Poison may not be used to kill animals, except rats, woodchucks, or other pests on one's own premises. The use of steel traps with spread of over 6 inches and "choke" traps with greater opening than 6 inches is unlawful as is also the use of snares or, except with consent of landowner, of scented baits.

Bag limits: Twenty-five raccoon a season.

Licenses: None required. Written consent of owner required to trap on land of another. Traps must be visited at least once in 24 hours. Animals may be removed from traps on Sunday, but traps may not be set or reset on such day.

Possession and sale: No restrictions on skins legally taken during open season.

Shipment and export: No restrictions on skins legally taken during open season.

Miscellaneous: Introduction of fox or raccoon in Dukes County prohibited.

Propagation: No legislation.

Bounties: Seal, $2 (by Commonwealth); wildcat or lynx, $5; paid by town, but refunded by county.

MICHIGAN.

Open seasons:[45]	*Dates inclusive.*
Beaver (see exception)	Nov. 1–Apr. 15.[46]
Exception: In Cheboygan, Montmorency, Otsego, and Presque Isle Counties	Closed until Dec. 20, 1922.
Otter, mink, fisher, marten	Nov. 16–Feb. 14.
Raccoon	Oct. 15–Dec. 31.
Muskrat,[46] in Manistee, Wexford, Missaukee, Roscommon, Ogemaw, Iosco, and all counties north thereof	Oct. 16–Apr. 14.
In rest of State	Dec. 16–Mar. 31.
Bear, skunk, wolf, coyote, fox, lynx, wildcat	Unprotected.

Prohibited methods: Unlawful to use spears, explosives, chemicals, mechanical devices, or smokers to drive animals from their holes or homes; to shoot muskrats except with a .22 caliber rifle, or to set a trap within 6 feet of a muskrat house or hole.

Licenses: Resident, $1; nonresident, $10; special beaver trapping license for taking 15 beaver, but not more than 4 from a single colony, $10; issued by county clerk. A hunting license also permits the holder to trap fur-bearing animals, except beaver. Minor children under 17 years of age may hunt or trap during open season on the enclosed lands of their parents upon which they live, without a license. License to hunt or trap on other lands issued to minors over 12 and under 17 on application of parent or guardian, but such licensed minors while hunting or trapping must be accompanied by parent or guardian.

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[44] *Massachusetts:* Fur animals unprotected in Dukes and Nantucket Counties.

[45] *Michigan:* Houses or dams of fur animals protected at all times. Fur animals, except beaver, may be destroyed under permit from commissioner, on one's own premises to protect property, but hides must be properly cared for and turned over to commissioner at expiration of permit. Unlawful to trap on State game preserves or to trap beaver, badger, or muskrat, in and within 2 miles of any city public park containing over 200 acres, of which 150 acres or more is woodland.

Possession and sale: Possession of beaver skins without license seal attached, or the carcass or skin of fur animals killed in close season prohibited.

Shipment and export: No restrictions on skins legally taken, possessed, or tagged.

Propagation: Annual license (fee, $5) required to engage in raising fur animals. Live animals and skins of animals raised in captivity must be tagged (fee, 5 cents for each tag).

Bounties: Wolf, $35; wolf cub under 6 months, $15; coyote, same as wolf; wildcat or lynx, $5; fox, $1; weasel, woodchuck, hawk, or owl, 50 cents; paid by county, one-half refunded by State. Boards of supervisors may pay additional bounties.

MINNESOTA.

Open seasons:	*Dates inclusive.*
Raccoon	Oct. 15–Mar. 1.
Mink, fisher, marten, muskrat	Dec. 1-Apr. 1.[46]
Beaver,[47] otter	No open season.
Black bear, skunk, weasel, wolf, wildcat, lynx, fox	Unprotected.

Prohibited methods: Unlawful to molest or destroy muskrat, mink, or beaver house, den, dam, or abiding place; to hunt these animals with dogs; or to take muskrats in any manner except by trapping.

Licenses: Resident only fee, $1; issued by commissioner, who also issues licenses (fee, $1, bond, $500) to trap a limited number of beaver in any locality; licensee must report number of beaver taken within 5 days after expiration of license. Owners, lessees, or members of their immediate families may hunt without license during open season on own or leased land occupied by them as permanent residence. Unlawful to enter growing grain for purpose of killing any wild animal without permission of owner.

Possession and sale: Skins of beaver legally taken, when tagged (fee, $3), and skins of other fur animals legally taken, may be possessed, bought, or sold at any time.

Shipment and export: Skins of beaver legally taken, when tagged (fee, $3), and other skins legally taken may be transported at any time. Export of red fox cubs taken in State prohibited. Package or receptacle containing wild animals or parts thereof when transported by a common carrier must have attached a proper coupon tag bearing signature, address, and license number of shipper together with number and kinds of animals or parts thereof contained therein.

Propagation: Wild animals raised in captivity under a $1 permit from the State game and fish commissioner may be sold for breeding or stocking purposes at any time, and under regulations of the commissioner may be killed and any part thereof sold or transported. Under regulations of the commissioner, wild animals may be captured during the open season for breeding purposes.

Bounties: Wolf, $7.50; cub wolf, $3; paid by State. County or town boards may offer bounty on wolf, gopher, ground squirrel, groundhog, rattlesnake, crow, or blackbird.

MISSISSIPPI.

Open seasons:	*Dates inclusive.*
Bear	Nov. 15-Mar. 1.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to trap bear.

Licenses: Nonresident, $20 (county license, bears only); issued by sheriff. Landowners and their nonresident relatives and friends may hunt without license during open season on own lands.

Possession and sale: Sale of bears prohibited.

Shipment and export: Export of bears prohibited. All packages containing dead animals, or parts thereof, shipped within the State shall be open to view, clearly marked with names of the consignor and consignee, and an itemized statement of the number of each species.

Propagation: No legislation.

Bounties: None paid.

MISSOURI.

Open seasons:	*Dates inclusive.*
All fur animals	Nov. 1-Jan. 31.[48]

Prohibited methods: Use of poison in taking any protected animal prohibited.

Licenses: None required. Written permission required to trap on inclosed premises of another.

Possession and sale: Unlawful to possess, sell, or offer for sale pelts of fur animals taken out of season.

Shipment and export: No restrictions, except that furs taken out of season may not be possessed for any purpose.

Propagation: Permits to capture fur animals for propagating purposes may be obtained from the State game and fish commissioner, fee, $5; breeder's permit, fee, $5.

Bounties: Adult wolf or coyote, $6; young wolf or young coyote, $3; paid by county and one-half refunded by State.

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[46] *Minnesota:* Owner may obtain permit to kill muskrat, mink, or beaver or to destroy their houses or dams when damaging his property.

[47] A limited number of beaver may be taken under a special license from the commissioner (*see* "Licenses").

[48] *Missouri:* Fur animals may be destroyed at any time and in any way to protect premises from their depredations, and pelts of animals so killed may be marketed.

MONTANA.

Open seasons:	*Dates inclusive.*
Marten	Sept. 15-May 1.
Beaver	No open season.[49]
Other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: Marten, $1; other fur animals (except beaver, wolf, coyote, and mountain lion), $1.50; special permit to trap beaver or to sell or ship their skins required; special license (trapping on State game preserves), $5; issued by State game warden.

Possession and sale: Sale and shipment of beaver skins prohibited, except that skins legally taken may be shipped or sold under permit from the State game warden by the persons killing the animals, but permittees must report name of purchaser and number of skins sold. No other restrictions on skins legally taken.

Shipment and export: (*See* Possession and sale.) No restrictions on skins legally taken, possessed, or tagged.

Propagation: No legislation.

Bounties: Grown wolf, $15; wolf pup, coyote, or coyote pup, $2.50; mountain lion, $10; paid from State bounty fund.

NEBRASKA.

Open seasons:	*Dates inclusive.*
Muskrat, otter, mink, raccoon, opossum	Nov. 1-Feb. 15.[50]
Beaver	No open season.[51]
Other fur animals	Unprotected.

Prohibited methods: Unlawful to destroy muskrat houses on premises of another. No other restrictions.

Licenses: None required. Consent of owner required to trap on premises of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation.

Bounties: Counties that have voted at any general election to pay bounties may pay for wolf, $6; coyote, $3; wildcat, $1; mountain lion, $3.

NEVADA.

Open seasons:	
All fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: No restrictions.

Shipment and export: Permit required to export beaver or other furs.

Propagation: Game or fur animals (except beaver) raised in a licensed preserve (fee, $10) may be sold or shipped at any time under invoice.

Bounties: Mountain lion, $5; lynx or wildcat, $2; paid by county. Counties pay bounty of 1½ cents each for pocket gophers when at least 100 heads are presented at one time.

The State board of live stock commissioners is authorized to pay bounty from funds derived from tax on horses, cattle, and hogs. The rewards for coyote, coyote pup, wildcat, or lynx are 75 cents each; for mountain lion, $5.

The State board of sheep commissioners is authorized to pay bounty from funds derived from tax on sheep, the payments being the same as those made by board of live stock commissioners.

NEW HAMPSHIRE.

Open seasons:[52]	*Dates inclusive.*
Sable, otter, fisher, mink, marten, muskrat,[53] skunk, fox[54]	Nov. 1-Feb. 28.
Raccoon	Nov. 1-Dec. 31.[54]
Beaver	No open season.
Other fur animals	Unprotected.

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[49] *Montana:* Unlawful to kill beaver, except under a special license from the State game warden, but taxpayers, owners of real estate in the State, or their authorized agents may kill beaver on their own premises for the protection of their ditches, dams, etc.; such killing must be reported in writing to the State game warden within 30 days.

[50] *Nebraska:* Season applies to trapping on premises of another, but fur animals, except beaver, may be taken at any time when necessary for the protection of property.

[51] Beaver damaging property may be killed on own land under a permit from chief deputy game and fish commissioner.

[52] *New Hampshire:* Fur or predatory animals may be killed at any time when destroying domestic animals or fowls.

[53] Muskrats may also be taken from the waters of the Connecticut River during the month of March.

[54] Raccoons and foxes may also be taken by use of dog and gun during the month of October.

Prohibited methods: Bear traps must be safeguarded in a substantial manner. Use of set guns or snares is prohibited. Unlawful to destroy a muskrat house or set a trap therein, thereon, or at the entrance thereof.

Licenses: Resident, $1; nonresident, $15; issued by commissioner or agents. License not required of resident landowners and their minor children to trap on own farm lands during open season. No person may trap on lands of which he is not the owner or lessee without permission of owner. All metal traps must be legibly marked or stamped with trapper's name, and must be visited at least once every 24 hours. Unlawful to take traps of another or to remove fur animals from them. Trappers are liable for any damage to domestic animals by traps.

Possession and sale: Possession of fur animals permitted only during open season, but skins legally taken may be bought or sold at any time.

Shipment and export: No restrictions on skins legally taken and possessed.

Miscellaneous: Unlawful to tear down or destroy any fence or wall, leave open any gate or bar, or trample, or destroy any crop on land of another while trapping or pursuing wild animals.

Propagation: Permit (fee, $2) required to propagate fur animals, game, or fish.

Bounties: Bear, $5; hedgehog, 20 cents; wildcat, $5; paid by State, through the selectmen of towns.

NEW JERSEY.

Open seasons:	*Dates inclusive.*
Skunk, mink, muskrat,[55] otter	Nov. 15–Apr. 1.
Raccoon	Oct. 1–Dec. 15.
Beaver, fox	No open season.[56]
Other fur animals	Unprotected.

Prohibited methods: Muskrat, skunk, mink, and otter may be taken by trap only, except in Salem County, above Mill Creek, where they may be taken in open season by firearms and light. Unlawful at any time to disturb the lodge or nesting chamber of muskrat.

Licenses: No trapping license required. Hunting license required in Salem County by those using firearms: fees, resident male citizen above age of 14, $1.15; nonresident, $10.15. Aliens (except those who own real estate in the State to the value of $2,000 above all encumbrances) not permitted to hunt, capture, or kill any wild animal, except in defense of person or property, and may not own or possess a shotgun or rifle. Aliens qualified to hunt must secure nonresident license.

Possession and sale: Possession of raccoon permitted during open season and 10 days thereafter; skins legally taken may be possessed or sold at any time. Possession of live fox prohibited except by permission of board of fish and game commissioners.

Shipment and export: Export of raccoon prohibited, except by nonresident licensee. No other restrictions on skins legally taken or possessed.

Miscellaneous: Unlawful to molest traps set by another or to take animals caught in such traps. Unlawful to liberate fox in State, except a club hunting with hounds and horses may liberate foxes caught in State for purpose of pursuit and capture.

Propagation: No restrictions except those imposed by close seasons, during which wild animals may not be taken for breeding purposes. Breeder's license fee, $5.

Bounties: Fox, $3; woodchuck, amount, not exceeding 50 cents, fixed by board of chosen freeholders; paid by counties.

NEW MEXICO.

Open seasons:	
Beaver	No open season.[57]
All other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: Permit from State game warden required.

Bounties: Coyote, wildcat, or lynx, $2; wolf, $15; panther or mountain lion, $10; paid from county wild-animal fund.

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[55] *New Jersey:* Muskrats may be killed at any time by owner of canal or dam which they are destroying.

[56] Board of fish and game commissioners may grant permits to hunt foxes with hound and firearms from the last day of the open season for deer (Dec. 25) to May 31.

[57] *New Mexico:* When destroying property beaver may be killed under permit from State game and fish warden.

NEW YORK.

Open seasons:	*Dates inclusive.*
Mink, sable	Nov. 10-Mar 15.
Skunk	Nov. 10-Feb. 10.[58]
Muskrat (see exception)	Dec. 1-Mar. 31.
Exception: In Clinton, Essex, Franklin, Hamilton, Jefferson, Lewis, St. Lawrence, Warren, Washington, and that portion of Herkimer County north of the towns of Ohio and Russia	Dec. 1-Apr. 20.
Raccoon	Nov. 10-Feb. 10.
Beaver	No open season.

Prohibited methods: Skunks may not be taken by the aid of dogs or by digging out or driving them from dens or holes by smoking or by the use of chemicals. Unlawful to kill muskrats by shooting, except they may be taken with a 22-caliber rifle in the counties bordering upon Lake Champlain; to take them in box, wire, or cage traps; or to molest, injure, or disturb muskrat houses or dens.

License : Resident, $1.10; nonresident, $10.50; issued by county, city or town clerks. Licensee required to wear button. Owners, tenants, and members of immediate families actually occupying cultivated farm lands may trap fur animals thereon without license during open season. Minors under 16 may trap fur animals without a license.

Possession and sale: Fur animals may be possessed during open season only, but hides of fur animals legally taken and possessed may be bought or sold at any time.

Shipment and export: Shipment and export prohibited, except hides of fur animals legally taken and possessed may be transported at any time.

Miscellaneous: Traps used for taking fur animals protected by law may not be staked or set during close season.

Propagation: Protected fur animals may be kept alive in captivity for propagation and sale, under license from the conservation commission (fee, $5). No fur-bearing animals may be kept which are taken wild during close season for such animals (unless taken under license); nor may they be disposed of during close season. The conservation commission is authorized to issue license to capture animals for propagation; fee for permit, $1.

Bounties: Panther, $20; paid by State,

NORTH CAROLINA.

[More than half of the 100 counties in the State have local laws relating to fur animals. Information regarding open seasons, license requirements, and trapping and hunting restrictions in the counties under the jurisdiction of the State Audubon Society may be obtained from the Secretary, Audubon Society of North Carolina, Raleigh.]

NORTH DAKOTA.

Open seasons:	*Dates inclusive.*
Mink, muskrat	Nov. 16-Apr. 14.[59]
Beaver	Jan. 10-Mar. 10.[60]
Otter	No open season.
Other fur animals	Unprotected.

Prohibited methods: Muskrat houses are protected at all times.

Licenses: Resident, $2 (for mink, muskrat, or beaver); nonresident, $25 (for mink and muskrat only); issued by commissioners, deputies, and county auditors. License not required of persons under 16 years of age, or of resident or member of family residing permanently with him, to trap on own cultivated land, during open season. Alien prohibited from hunting, taking, or killing any wild animal, except in defense of person or property.

Possession and sale: Skins of fur animals killed within or without the State may be possessed or sold at any time. Green hides of mink or muskrat may be possessed only during open season and first 5 days of close season.

Shipment and export: Shipment and export prohibited, except skins of fur animals legally taken within or without the State may be shipped at any time.

Propagation: The State game and fish board issues permits (fee, $5) to breed and domesticate mink, muskrat, skunk, and raccoon, and also permits to sell or ship them when raised in captivity. Under permit from board and $500 bond, wild fur animals may be taken at any time for breeding purposes. Annual reports are required of licensed breeders.

Bounties: Wolf, coyote, $2.50.

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[58] *New York:* If injuring property, skunks may be taken at any time and in any manner, but the skins of animals so taken shall not be possessed, sold, bought, or trafficked in.

[59] *North Dakota:* Mink or muskrat may be killed at any time to protect one's own property.

[60] Unlawful to trap beaver on posted lands of another.

OHIO.

Open seasons:[61]	*Dates inclusive.*
Raccoon, mink, skunk, opossum	Nov. 1–Feb. 1.
Muskrat	Dec. 1–Mar. 1.
Fox	Oct. 2–Jan. 1.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to dig out or destroy the house, den, or burrow of fur animals or to smoke or drown the animals therefrom.

Licenses: Resident, $1; nonresident, $15; issued by county and township clerks. Alien prohibited from hunting or trapping. License not required of owners, managers, tenants, or their children to trap during open season on own land. Written permission from owner or authorized agent required to trap on lands of another.

Possession and sale: Possession of fur animals during close season prohibited, but skins legally taken may be possessed or sold at any time. Raccoons legally taken may be possessed alive in inclosures as pets.

Shipment and export: Shipment and export prohibited, except that skins legally taken may be transported at any time. Packages containing fur animals or parts thereof when transported by common carrier must be marked to show contents, initial point of billing, and names and addresses of consignor and consignee.

Propagation: No restrictions, except those which prevent capture of wild stock in close season.

Bounties: Townships pay a bounty of $1 each on certain hawks and great horned owl; 20 cents a dozen on English sparrows; and, under certain conditions, 10 cents each on groundhogs.

OKLAHOMA.

Open seasons:	*Dates inclusive.*
Beaver, otter	No open season.
Bear (see exception)	Unprotected.
Exception: In Blaine, Caddo, Comanche, Kiowa, and Major Counties	No open season.
Other fur animals	Nov. 1–Mar. 1.

Prohibited methods: No restrictions.

Licenses: None required.

Possession and sale: Unlawful to sell pelts of fur animals taken during close season. No other restrictions.

Shipment and export: No restrictions on skins legally taken.

Propagation: The State game warden issues permits to propagate fur-bearing animals, game, and fish; cost, $2, together with fees for tagging. Licensed breeders may sell and transport animals raised in preserves under rules prescribed by the warden.

Bounties: County commissioners are authorized to offer bounty on gray wolf ($3) and coyote ($1), and may also pay bounties on hawks, crows, or other birds or animals destructive of game or insectivorous birds.

OREGON.

Open seasons:[62]	*Dates inclusive.*
Mink, otter, fisher, marten, muskrat[63]	Nov. 1–Feb. 28.
Beaver[63]	No open season.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to destroy muskrat house, except where it obstructs ditch or watercourse.

Licenses: Required of any person over 16 years of age to trap on land other than his own premises: fee, $1; issued by board of fish and game commissioners. Unlawful to remove or disturb traps of a licensed trapper on public domain or on lands where he has permission to trap. Licensed trappers are required to make annual reports of number of animals caught and receipts for fur sold.

Possession and sale: Possession and sale prohibited, except that animals or hides legally taken within or without State may be possessed or sold at any time.

Shipment and export: Shipment and export prohibited, except skins of animals legally taken may be shipped at any time.

Miscellaneous: Unlawful to use the flesh of a game bird or animal for trap bait.

Propagation: Permits (fee, $2) to keep fur-bearing animals may be obtained from the State board. No wild fur-animals may be taken for propagating purposes in close season nor may those held in captivity under permit be sold in that season. Yearly reports to the State board are required.

Bounties: Coyote or coyote pup, $3; adult female coyote, $4; gray, black, or timber wolf, or wolf pup, $2.50; bobcat, wildcat, or lynx, $2; mountain lion, panther, or cougar, $10; seal or seal pup, $2.50; paid by county and half refunded by the State. The State board is empowered to pay additional bounties on any predatory animal in order to protect game; under this act it now pays for wolf, $20; for cougar, $15. Several counties are authorized to pay bounties on moles, rabbits, and gophers.

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[61] *Ohio:* Protected fur animals, when damaging property, may be destroyed by owners or tenants of land (except on Sunday).

[62] *Oregon:* Unlawful to hunt or trap fur animals on State game preserve.

[63] If beavers or other fur animals damage property, permits to kill them may be obtained from the State game warden, but skins of animals so taken must be delivered to the board of fish and game commissioners, to be sold by them and the proceeds used in paying for damage to property.

PENNSYLVANIA.

Open seasons:	*Dates inclusive.*
Bear[64]	Oct. 15–Dec. 15.
Raccoon[65]	Sept. 1–Dec. 31.
Muskrat, skunk	Nov. 16–Feb. 28.[66]
Fox (see exception), wildcat, mink, weasel, opossum	Unprotected.
Exception: Fox, in Chester, Delaware, and Montgomery Counties.	No open season.
Beaver	No open season.

Prohibited methods: Unlawful to trap bear. Steel traps larger than No. 3 size may not be used for trapping wildcats or other animals classed as vermin. Unlawful to dig out skunk or muskrat; to drive them from holes or dens by use of smoke or chemicals; or to hunt them at night with dogs.

Bag limits: One bear a season, or 3 to a camp or body of men.

Licenses: Nonresident, $10; resident (hunting license for raccoon or bear), $1 (fee of 15 cents extra to justice of peace); issued by commission, county treasurer, or justice of the peace. Hunting license not issued to minor under 14 years of age, and minor between 14 and 16 must furnish written consent of parent or guardian. Licensee required to wear tag. Resident citizen and members of family residing on and cultivating land may hunt on such land, and, with consent of owner, on adjoining land, without a license, during open season. Alien not permitted to hunt or kill any wild animal in State, except in defense of person or property.

Possession and sale: Bear may be possessed only during open season and first 30 days of close season. Raccoon taken during open season may be possessed or sold at any time. No other restrictions on skins legally taken.

Shipment and export: Raccoons legally taken may be shipped or exported at any time. Packages must be plainly marked to show contents, name and address of owner, and county in which taken. Shipment by parcel post prohibited. Nonresident licensee may take out 1 bear legally killed. No other restrictions on skins legally taken and possessed.

Propagation: No restrictions on raising fur animals, except that possession and breeding of ferrets is unlawful except under license from State board of game commissioners; fee for license to breed and sell ferrets, $25; to possess a ferret without breeding, $1.

Bounties: Wildcat, $8; fox, $2; mink, $1; weasel, $2; paid from special fund created by setting aside one-half the receipts by the board of game commissioners from gun licenses, fines, etc. Affidavit on form supplied by game commission must accompany entire unmutilated skin of animal when presenting claim to board of game commissioners, at Harrisburg, Pa.

PORTO RICO.

Porto Rico has no wild fur animals.

RHODE ISLAND.

Open seasons:[67]	*Dates inclusive.*
Skunk	Nov. 1–Apr. 15.
Raccoon, muskrat, mink, otter	Oct. 1–Feb. 1.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to set wire snares, or to use steel traps with teeth or with spread over 6 inches, or choke traps with greater opening than 6 inches. Traps must be concealed so as not to endanger domestic animals and must be visited at least once every 24 hours.

Licenses: Hunting license required for trapping: resident, $1.15; nonresident, $10.15; alien, $15.15; issued by town and city clerks. License not required of resident or his immediate family to hunt or trap on agricultural lands on which actually domiciled; nonresident owning real estate valued at not less than $500, and nonresident member of club incorporated for hunting or fishing purposes prior to Jan. 1, 1909, which owns real estate assessed for taxation at value of not less than $1,000, may procure license at a fee of $1.15; licenses not issued to minors under 15 years of age. Written permission required to trap on posted lands of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No legislation.

Bounties: Fox, $3; crow and certain hawks and owls, 25 cents; paid by State.

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[64] *Pennsylvania:* Bear may be killed at any time in defense of person or property. The board of game commissioners, upon petition of 200 citizens of a county showing that bear have become a nuisance may permit them to be taken at any time, but steel traps and deadfalls may not be used. Animals so taken may be disposed of only by the person taking them.

[65] Raccoon may be killed by landowners or tenants and their employees at any time to protect their growing crops.

[66] Landowners, tenants, members of families, and employees may take skunk or muskrat on own lands at any time.

[67] *Rhode Island:* Landowner may kill fur animals on own land at any time.

SOUTH CAROLINA.

Open seasons:	*Dates inclusive.*
Bear, mink, muskrat, opossum, otter, raccoon, skunk	Oct. 1–Mar. 15.
Fox	Sept. 1–Feb. 15.[68]
Other fur animals	Unprotected.[69]

Prohibited methods: Hunting at night prohibited except for raccoon, opossum, or fox. Unlawful to shoot or trap foxes, to dig them out of the ground, or to push or drag them out of a tree or log.

Licenses: Hunting license required: resident, county license, $1.10; State, $3.10; issued by county clerk or game warden; nonresident, $15.25; issued by county clerk. No license required of resident owners, tenants, their children, or, under written permission, their employees to hunt during open season on own lands. Consent of owner or manager required to hunt or trap on lands of another.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: Shipments must be labeled to show the number and kind of animals in the package and the consignor and consignee. No other restrictions on skins legally taken.

Propagation: No legislation.

Bounties: None paid.

SOUTH DAKOTA.

Open seasons:	*Dates inclusive.*
Mink, muskrat, skunk (season opens at noon and closes at noon)	Dec. 1–Mar. 1.[70]
Beaver,[70] otter	No open season.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to shoot muskrats, or to destroy or molest muskrat houses, except these may be opened without injury thereto for the purpose of placing traps therein during open season. No person may set or operate more than 75 traps at any one time.

Licenses: Resident, $5; nonresident, $25; issued by game warden and county treasurer. License not required of residents under 14 years of age, nor of landowners trapping on own lands during open season. Unlawful to hunt on cultivated or posted lands of another without permission of owner.

Possession and sale: Unlawful to possess, buy, or sell raw skins of protected fur animals during close season, whether taken or killed within or without State.

Shipment and export: Unlawful to ship raw skins of protected fur animals during close season, whether taken or killed within or without State.

Propagation: Not permitted.

Bounties: State pays $5 for each grown buffalo, black, or gray timber wolf; $2 for each pup thereof; mountain lion, $3; coyote or prairie wolf, $2; proportionate amount paid if the appropriation is not sufficient to pay full bounties. A county may pay $4 for coyote and $8 for wolf, killed within the county.

TENNESSEE.

Open seasons:[71]	*Dates inclusive.*
All fur animals (season opens at noon and closes at noon) (see exceptions)	Oct. 15–Jan. 15.[72]
Exceptions:	
Cannon, Chester, Dickson, Lewis, and Stewart Counties: All fur animals	Unprotected.
Blount, Carter, Greene, Johnson, Unicoi, and Washington Counties: Fox	No open season.[73]
Cocke, Meigs, and Rhea Counties: Foxes	No open season.[74]
Davidson, Robertson, and Shelby Counties: Beaver, muskrat, fox, mink, raccoon, skunk, opossum	Sept. 1–Jan. 31.[71]
Dyer County: Raccoon, mink, otter	Oct. 1–Feb. 15.[71]
Franklin County: Beaver, muskrat, fox, mink, raccoon, skunk, opossum	Nov. 1–Jan. 31.
Greene County: Fox	Nov. 1–Mar. 1.[75]
Muskrat	Dec. 15–Mar. 15.
Other fur animals	Dec. 15–Feb. 15.
Hawkins County: All fur animals	Nov. 15–Jan. 15.[74]
Smith County: All fur animals	Oct. 15–Feb. 15.[76]
Warren County: All fur animals	Nov. 1–Feb. 28.

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[68] *South Carolina:* Foxes doing damage may be shot on one's own premises at any time.

[69] Wildcats may be killed without license at any time by officers of the law and landowners upon their own holdings.

[70] *South Dakota:* Skunks doing damage around buildings may be killed at any time, and, under permit from State game warden, muskrat or beaver damaging irrigation ditches, embankments, or public highways may be taken at any time.

[71] *Tennessee:* Fur animals may be taken on one's own land at any time.

[72] In *Claiborne, Grainger, Davidson, Roane,* and *Shelby Counties* it is unlawful to set a trap more than 200 yards from trapper's residence.

[73] In *Blount, Carter, Greene, Johnson, Unicoi,* and *Washington Counties* traps may be set near farm buildings and foxes may be killed when they destroy fowls or live stock.

[74] In *Cocke, Hawkins, Meigs,* and *Rhea Counties* foxes may be chased or killed with dogs or killed when injuring poultry or live stock.

[75] In *Greene County* fox destroying domestic fowl may be killed at any time.

[76] In *Smith County* fur animals may be killed at any time to protect property.

Prohibited methods: Steel traps must be placed at least 12 inches within the entrance to a hole, cave, den, or hollow log.

Licenses: None required. Written consent required to trap on lands of another. Traps and deadfalls must be inspected within each 36 hours, and captured animals removed; does not apply to trapping wildcats in Lauderdale County.

Possession and sale: No restrictions, except locally. In Davidson, Franklin, Robertson, and Shelby Counties the sale of protected fur animals is prohibited from February 1 to October 31. In Meigs and Rhea Counties the sale of live foxes or pelts of foxes caught or killed in said counties is prohibited.

Shipment and export: No restrictions except locally. In Davidson, Franklin, Robertson, and Shelby Counties it is unlawful to remove any protected fur animal from county.

Propagation: No legislation.

Bounties: Wolf or panther, $2-certificate issued by county court, the amount to be applied on payment of taxes

TEXAS.

Open seasons:

All fur animals (see exception)	Unprotected.
Exception: In Caldwell County, mink, raccoon, fox	No open season.

Prohibited methods: No restrictions.

Licenses: None required. Consent of owner necessary to trap on posted land.

Possession and sale: No restrictions.

Shipment and export: No restrictions.

Propagation: Permit must be obtained from game, fish, and oyster commissioner to trap or transport wild animals for propagation.

Bounties: None paid.

UTAH.

Open seasons:

Beaver, otter, marten	No open season.[77]
Other fur animals	Unprotected.

Prohibited methods: No restrictions.

Licenses: None required. Aliens other than homesteaders are not allowed to hunt or trap.

Possession and sale: Possession and sale of skins or any part of protected fur animals prohibited unless duly tagged by commissioner.

Shipment and export: Shipment and export prohibited, except commissioner may ship beaver killed under permit and tagged.

Propagation: No legislation.

Bounties: Wolf, $62.50; bear, mountain lion, cougar, $30; coyote, $4; lynx, bobcat, $3.

VERMONT.

Open seasons:[78]	*Dates inclusive.*
Mink, otter, muskrat (see exception)	Nov. 1–Apr. 30
Exception: On shores of Lake Champlain in Rutland County, Poultney River below Carvers Falls, and shores of Lake Memphramagog in Orleans County	Jan. 1–Apr. 30.
Marten, raccoon, fisher, skunk	Oct. 20–Mar. 31.
Fox	Oct. 20–Apr. 1.[79]
Beaver	No open season.
Other fur animals	Unprotected.

Prohibited methods: The use of set guns is prohibited, and bear traps must be carefully safeguarded. Unlawful to open or destroy a muskrat house or to place a trap at its entrance. Unlawful to dig skunks from dens or to drive them out by use of smoke or chemicals.

Licenses: Resident, 60 cents; nonresident, $10.50; issued by town clerk. Owners of farm lands and their resident minor children or tenants may take fur animals on own lands during open season without a license. License not issued to person under 16 years of age without written consent of parent or guardian. Nonresident owning improved real estate appraised at not less than $1,000, upon which he pays taxes, may obtain a resident license. Persons trapping on inclosed lands of another must, within 12 hours, inform owner of location and number of traps and must visit traps at least once in 24 hours.

Possession and sale: Possession of fur animals during close season prohibited, but the fur or skins of animals legally taken may be possessed, bought, or sold at any time.

Shipment and export: Packages containing fur animals or parts thereof delivered to a common carrier for transportation must be tagged to show the number and kind of such animals or skins therein, names of consignor and consignee, station from which shipped, and destination. A person required to have a license must also show the number of his license on the shipping tag. No other restrictions on skins legally taken and possessed.

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[77] *Utah:* When beaver are destroying property, the State fish and game commissioner may grant permits to kill them, but the hides of animals so taken must be delivered to and sold by commissioner, who may recompense for trapping in not more than one-half of the proceeds from sales.

[78] *Vermont:* Fur animals may be killed at any time to protect one's own property.

[79] Fox may be taken otherwise than by trapping at any time.

Propagation: The State fish and game commissioner issues special permits for propagating fur and game animals (fee, $2 and expense of tagging). Animals bred on fur farms may be sold and transported alive at all times when bearing the identification tags prescribed by the commissioner.

Bounties: Black bear taken between May 1 and November 1, $10; hedgehog (porcupine), 15 cents; paid by State. Towns pay $5 bounty on bay lynx or bobcat.

VIRGINIA.

Open seasons:	*Dates inclusive.*
All fur animals (season opens at noon and closes at noon) (see local laws)	Oct. 15–Jan. 15.[80]
Jefferson magisterial district—in Culpeper County: Fox (trap)	Nov. 1–Dec. 31.[81]
Fauquier and Loudoun Counties: Fox	Sept. 1–Mar. 31.[82]
Halifax County: Opossum	Oct. 15–Jan. 31.
King George County: Muskrat	Dec. 20–Mar. 31.
Loudoun County: Mink, muskrat, skunk	Nov. 1–Feb. 28.
Opossum, raccoon	Oct. 1–Feb. 28.
Nansemond County: Mink, otter, muskrat	Jan. 1–Mar. 31.
Patrick County: Raccoon, opossum	Oct. 15–Mar. 14.
Gray fox	Sept. 15–Mar. 14.
Princess Anne County: Mink, muskrat, otter (for profit)	Nov. 1–Mar. 14.

Prohibited methods: Unlawful to shoot muskrats at night with aid of lights in tidewater sections of State.

Licenses: None required; except in Loudoun County (fee $2.50), to trap on lands of another. In Loudoun and Rappahannock Counties, written permission is required to trap or hunt on lands of another.

Possession and sale: No restrictions except in Patrick County, where the sale of protected fur animals during close season is prohibited.

Shipment and export: No restrictions.

Propagation: License required (fee, $25) to raise game or fur animals.

Bounties: None paid.

WASHINGTON.

Open seasons:	*Dates inclusive.*
Bear	Sept. 1–May 1.[83]
Beaver	No open season.
Other fur animals	Unprotected.

Prohibited methods: No steel trap larger than No. 4 may be used unless a notice in the English language on a large placard is placed above the trap.

Licenses: County, $5; issued by county auditor. Not required to trap coyote, muskrat, mink, skunk, marten, civet cat, weasel.

Possession and sale: Sale of protected animals is prohibited at all times and possession is prohibited during closed season, except under permit, but beaver skins secured without the State, after being inspected and stamped by the game warden, may be possessed or sold at any time.

Shipment and export: Shipment and export of protected animals and their skins prohibited, but bears legally taken may be shipped within State under affidavit that they are not shipped for sale or profit.

Propagation: Breeder's license (fee, $10; renewal, $5) required.

Bounties: Mountain lion or cougar, $20; lynx or wildcat, $5; coyote, $1; timber wolf, $15; seal or sea lion in Columbia River district, $1; paid by State. Counties are permitted to pay additional rewards for destroying these animals, and also bounties on bear, muskrat, and squirrel.

WEST VIRGINIA.

Open seasons:[84]	*Dates inclusive.*
Red fox, skunk[85] in Brooke, Cabell, Clay, Doddridge, Grant, Harrison, Marion, Mineral, Mingo, Monongalia, Morgan, Nicholas, Ohio, Pleasant, Ritchie, Roane, Summers, Taylor, Upshur, Wetzel, Wirt, and Wyoming Counties only	Dec. 1–Feb. 1.
In rest of State	Unprotected.
Raccoon, mink, and other fur animals	Unprotected.

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[80] *Virginia:* Law applies to any county after adoption by the board of supervisors. Trapping on lands of another is unlawful except from noon of Oct. 15 to noon of Jan. 15, and then is lawful only with written permission of landowner, which permission the trapper must have on his person when trapping. He must visit traps at least once every 36 hours and is liable for any damage such traps may do to domestic animals. Landowner may trap or kill fur animals on his own lands at any time.

[81] Traps must be visited daily in Jefferson magisterial district, Culpeper County.

[82] Fox may be taken at any time by owner or tenant of land to protect property in Fauquier and Loudoun Counties. Written permission of owner required to take foxes on lands of another.

[83] *Washington:* Bear may be killed at any time when destroying domestic animals.

[84] *West Virginia:* A landowner, his agent, or tenant may hunt or kill fur animals on his own lands at any time.

[85] Any county may by majority vote provide a perpetual close season on skunk.

Prohibited methods: Unlawful to set a steel or spring bear trap on land of another.

Licenses: Hunting license required to trap: Resident, $1; nonresident, $18; issued by county clerk. Resident landowner, his children or tenants, may hunt during open season on own land without a license. License not issued to minor under 15 without written consent of parent or guardian. Express permission of owner or tenant required to set or maintain a snare or trap upon land of another. Licensee must wear tag.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: No restrictions on skins legally taken.

Propagation: No restriction on possession or sale, but animals must not be taken for breeding purposes in close season except on lands owned or tenanted by the breeder.

Bounties: Wildcat, bobcat, or catamount, $5; crow, 10 cents; certain hawks and owls, 25 cents; paid from forest, game, and fish protection fund.

WISCONSIN.

Open seasons:	*Dates inclusive.*
Beaver	No open season.[86]
Fisher, marten, mink (see exception), skunk	Nov. 15–Feb. 1.
Exception: Mink in Brown, Oconto, and Washington Counties	No open season.[87]
Raccoon (see exception)	Oct. 15–Jan. 1.
Exception: In Marathon County	Aug. 15–Jan. 1.
Muskrat[86] in Ashland, Barron, Bayfield, Burnett, Douglas, Florence, Forest, Iron, Langlade, Lincoln, Marinette, Oneida, Polk, Price, Rusk, Sawyer, Vilas, and Washburn Counties	Oct. 25–Apr. 20.
In Brown, Oconto, and Washington Counties	No open season.[87]
In Calumet, Manitowoc, and Sheboygan Counties	Mar. 1–Apr. 15.
In remainder of State	Nov. 15–Apr. 1.
Black bear	Unprotected.

Prohibited methods: Unlawful to take fisher, marten, mink, or muskrat with the aid of spear, gun, or dog; to disturb or molest muskrat houses, beaver houses, or beaver dams; to set traps within 500 feet of any beaver dam or beaver house; or to molest or disturb raccoon den trees for the purpose of capturing raccoons.

Bag limits: Five raccoons a day.

Licenses: Resident, $1; issued by conservation commission. Report required from licensed trapper on or before June 1 of each year. Nonresident not permitted to trap; alien not permitted to hunt.

Possession and sale: Possession and sale of beaver or skins thereof prohibited; possession of green skins of fur animals permitted only during open season and first five days of close season; possession prohibited of the skin of fisher, marten, mink, or muskrat which shows that the animal has been shot or speared. No other restrictions on possession and sale of skins legally taken.

Shipment and export: Shipment and export of beaver prohibited; shipments of hides must be marked to show the number and kinds of hides, the name and address of the shipper, and the number of his trapping license.

Propagation: Under permit and supervision of the commission wild animals may be taken and transported for propagation within the State. Special license required for muskrat farming (fee, $5, and 1 cent per acre for all premises in excess of 500 acres covered by the license).

Bounties: Wolf cub taken between March 1 and November 1, $4; mature wolf killed at any time, $10; fox, $2; paid by county. County boards may increase these rewards, but no county may pay more than $6 for killing a wolf cub. The State treasurer duplicates all county awards, thus doubling the above bounties. Poisons may be used for destroying animals for bounty between December 1 and March 1, but notice of putting out baits must be posted, and they may not be placed within 80 rods of a dwelling house. County boards may offer bounty on crow, hen hawk, pocket gopher, streaked gopher, English sparrow, blackbird, or rattlesnake.

WYOMING.

Open seasons:	
Beaver	No open season.[88]
All other fur animals	Unprotected.

Prohibited methods: Unlawful for nonresident to trap bears.

Licenses: For trapping in State game preserves, fee, $3; for trapping fox, mink, or marten in national forests, $3; issued by State game warden. Employees of the Federal Government do not require permit to trap predatory animals. For bear, nonresident, $10; issued by justices of the peace, assistants, and deputy game wardens. Dog license, $1 (required for each dog used in hunting predatory animals in national forests during close season on big game).

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[86] *Wisconsin:* If beaver damage property, they may be captured and removed under permit and the direction of the State conservation commission; skins of animals that are killed in taking must be delivered to the conservation commission. Owners or lessees of dams, under permit of conservation commission, may destroy at any time muskrats to protect such dams or levees, but they may not sell, barter, or give away the skins of such animals killed during close season.

[87] Expires in 1921.

[88] *Wyoming:* Close season on beaver expires March 15, 1925. If beaver damage real estate the owner thereof may destroy them, but must furnish State game warden with affidavit showing damage and number killed.

Possession and sale: Skins of beaver killed when doing damage to real estate may be possessed when duly tagged by warden and affidavit is furnished the warden by owner of the real estate showing the damage and numbers of beaver killed.

Shipment and export: Beaver hides must be tagged by warden before being shipped or transported.

Miscellaneous: Use of the flesh of game animals or birds as trap bait for predatory animals prohibited.

Propagation: No legislation.

Bounties: None paid by State.

LAWS OF CANADA.

ALBERTA.

Open seasons:[89]	*Dates inclusive.*
Mink, fisher, marten	Nov. 1–Mar. 31.[90]
Otter, muskrat (see exception)	Nov. 1–Apr. 30.
Exception: Muskrat, south of North Saskatchewan River	No open season.[90]
Beaver	Dec. 31, 1925.[90]
Fox and other fur animals	Unprotected.[91]

Prohibited methods: Unlawful to use poison for taking fur animals; or to destroy, partially destroy, or to leave open any muskrat or beaver house.

Licenses: *Trapping:* None required of residents; nonresident, $25; issued by minister of agriculture. Consent of owner or occupant required to trap on inclosed or cultivated lands of another. Permits to trap on game or forest reserves may be granted under regulations of the lieutenant governor in council. *Taxidermist,* $5. *Dealer* in furs and skins of protected animals: Resident, branch office, and traveling agent, $5 each; nonresident, $100. Licensee must make monthly and annual reports to department of agriculture. License to export skins, $1; issued by minister.

Possession and sale: No restrictions on possession and sale of skins legally taken and possessed.

Shipment and export: Export of furs and skins prohibited except by holder of a license. No furs or skins on which royalty has not been paid may be exported, and a special permit from the minister is necessary to ship out unprime skins. Resident hunter or trapper exporting furs or skins of animals taken by himself is not required to pay royalties on skins so exported unless the tax exceeds the sum of $10 in any one year. Export of live fox prohibited.

Propagation: Manager of fur farm required to make reports January 1 and July 1 of each year. Export of live animals from fur farms allowed only on permit from the minister of agriculture. Permit, with fees, required to export live muskrat, mink, fisher, marten, otter, or beaver, whether raised on a fur farm or otherwise (orders in council).

Bounties: The council of any rural municipality is authorized to offer a bounty on wolf.

BRITISH COLUMBIA.

Open seasons:[92]	*Dates inclusive.*
Bear (see exception)	Sept. 1–June 30.
Exception: Unlawful to trap bear south of main line of Canadian Pacific Railway.	

Prohibited methods: Unlawful to use poison in taking fur animals, except farmers and poultrymen may protect own stock.

Licenses: *Trapping:* Resident, $10; nonresident not permitted to trap; nonresident (special license to hunt—not trap—bear from January 1 to July 1), $25; nonresident general hunting license, fee, $25 and additional fees of $15 to $25 for each bear killed. License not issued to boys under 18 years of age without written consent of parent or guardian. Issued by Provincial game warden or authorized agent. Licensee must wear badge. No license required of a resident to trap on own land during open season. Permission of owner required to trap on inclosed, cleared, or cultivated land of another. A licensed trapper who first occupies a trap line prior to November 14 is protected against other trappers. Unlawful to touch or interfere with traps set by a licensed trapper. License must be returned within two months after it expires, with a statement of number of fur animals of each kind taken. *Fur dealer:* Resident, $25 (does not apply to licensed trapper selling skins taken by himself); nonresident or his agent, $200. License required for each place of business. Fur dealer must make verified report on or before August 31 showing number and kinds of skins purchased and date of transactions. *Taxidermist,* $5. Game conservation board may grant permits (fee, $25) to buy furs at wholesale from licensed fur dealers or at public auction.

Possession and sale: Unlawful to sell pelts taken during close season. Possession of pelts of fur animals allowed only during open season and for two months thereafter (three months, north of 52d parallel), except under special permit from Provincial game warden. Unlawful for fur trader to possess skins on which royalty has not been paid. Does not apply to skins taken by a licensed trapper if sold to a licensed resident dealer nor to skins of animals raised in captivity.

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[89] *Alberta:* Unlawful to destroy a beaver dam, unless authorized to do so by the lieutenant governor in council, who may also authorize the killing of beaver or other fur animals when such killing is deemed to be in the public interest.

[90] Lieutenant governor in council may declare open seasons locally on beaver and muskrat.

[91] Unlawful to trap fox for export.

[92] *British Columbia:* Seasons on fur animals fixed annually by lieutenant governor in council. For regulations, apply to Secretary, Game Conservation Board, Vancouver, British Columbia.

Shipment and export: Export of pelts of fur animals allowed only during open season and for two months thereafter (three months, north of 52d parallel), under special permit of Provincial game warden. Packages must be prepared so that they may be easily opened for examination, or labeled with a full description of the contents, and names and addresses of the consignor and consignee.

Propagation: A permit from the game conservation board is required to propagate fur-bearing animals. Breeder must keep a record of transactions as to purchases and sale of stock, which record must be open to inspection of any game warden, and must make verified report to game conservation board on or before August 31. Live foxes may be exported only under permit, and a permit is required to take foxes or other fur animals in close season.

Bounties: Rates fixed from time to time by lieutenant governor in council.

MANITOBA.

Open season:[93]

North of fifty-third parallel.	*Dates inclusive.*
Fisher, pekan, sable, marten, mink	Nov. 1–Mar. 31.
Otter, beaver	Nov. 1–Apr. 30.
Muskrat (additional season, Nov. 1–30)	Mar. 15–May 15.
Fox, lynx	Nov. 1–Feb. 28.
South of fifty-third parallel:	
Fisher, pekan, sable, marten, mink	Nov. 1–Mar. 31.
Beaver,[94] otter	No open season.
Muskrat	Mar. 15–Apr. 30.
Fox, lynx	Unprotected.

Prohibited methods: Use of poison in taking fur animals is prohibited. Unlawful to shoot or spear muskrats or to destroy muskrat houses.

Licenses: *Trapping:* Resident, $2; nonresident Canadian citizen, $25; nonresident alien, $100; issued by minister of agriculture and immigration. Permission of owner required to trap on cultivated or inclosed lands of another. Licensee must return his license and make a report during the month of June showing the number of each kind of animal taken. *Fur trading:* Wholesale raw fur dealer, $50; raw fur buyer, $25; resident raw fur merchant or trader, $10; resident traveling agent, $10; issued by minister. Licensees are required to keep record and to make annual returns before September 30. *Fur dressing and tanning:* $10; issued by minister. Licensee must keep records and report to the chief game guardian on or before the 10th of each month the number of royalty pelts handled and the name and address of person forwarding or delivering the skins.

Possession and sale: Possession of unprime skins prohibited. Unlawful to purchase or sell the skins of muskrats that have been speared or shot. Any person purchasing or acquiring pelts from a trapper must ascertain that he holds proper trapping permit and at the same time record his name and the number of his permit. Unlawful to purchase, barter, or trade the pelt of a fur animal taken during close season (does not apply to imported skins). No other restrictions on skins legally taken.

Shipment and export: Export prohibited of unprime skins or skins on which royalty is payable unless such skins have coupons attached to show royalty paid; each shipment must have attached a declaration of the number and kinds of skins contained, and also set forth that royalty coupons are attached as required. No other restrictions on skins legally taken. Export prohibited of live protected animals (except ranch-bred animals) except under permit from minister of agriculture and immigration (permit must accompany shipment to destination); fees, for black or silver fox, $100; for other fox, $15; for otter, $25; for beaver, $5; for mink, fisher, or marten, $1; for muskrats, $2 a dozen or fraction thereof.

Propagation: License (fee, $5) must be obtained from the minister of agriculture and immigration to operate a fur farm. Licensee, on or before the first days of January and July, must make verified reports showing the number, species, age, and sex of the animals on hand, from whom procured, and the number which have died during previous six months, with cause of death.

Bounties: Timber wolf,[95] $5; other wolf,[95] $2; half is refunded to municipality by the Provincial treasurer.

NEW BRUNSWICK.

Open seasons:	*Dates inclusive.*
Mink, otter, fisher	Nov. 1–Mar. 31.
Fox	Oct. 1–Mar. 1.
Muskrat (season opens at noon and closes at noon)	Mar. 25–May 1.
Beaver, sable	No open season.[96]
Other fur animals	Unprotected.

Prohibited methods: Unlawful to take fur animals by use of poisons, or to dig out foxes from their homes or earth burrows.

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[93] *Manitoba:* Trapping in Provincial game preserves prohibited.

[94] Chief game guardian may take necessary steps to prevent beaver doing damage, but no beaver dams may be disturbed between Oct. 1 and Apr. 1.

[95] Poison may not be used to capture wolves for bounty.

[96] *New Brunswick:* Expires Dec. 31, 1923. Holder of permit from minister may take beaver from Nov. 1 to Apr. 1.

Licenses: *Trappers and fur dealers:*[97] Persons domiciled in Province, $10; all other persons, $50. Trappers and fur dealers must furnish the minister with written declarations showing their names and addresses, the location of warehouses, shops, posts, or caches where skins are to be stored, and the places from which the skins will be shipped out of the Province, and must make monthly reports of operations. Issued by minister of lands and mines. License is required to traffic in, cure, or tan skins: Resident, $10; nonresident or resident alien, $50; issued by minister. Special license (accompanied by necessary tags) to trap beaver from Nov. 1 to Apr. 1 may be issued by minister: fee, $8 for each animal.

Possession and sale: Possession prohibited of furs on which royalties, as fixed by lieutenant governor in council, have not been paid; possession of green skins or carcasses of protected fur animals in close season prohibited.

Shipment and export: No restrictions on skins legally taken, possessed, or tagged.

Propagation: Permits to capture wild fur-bearing animals for propagation within the Province may be obtained from the minister of lands and mines, who fixes the fee for such permit.

Bounties: None paid.

NORTHWEST TERRITORIES.[98]

Open seasons:[99]	*Dates inclusive.*
Mink, fisher, marten	Nov. 1-Mar. 14.
Otter, beaver, muskrat	Oct. 1-May 14.
White fox	Nov. 15-Mar. 31.

Prohibited methods: Unlawful to use poison in taking fur animals or to destroy or injure any beaver or muskrat house.

Licenses: *Trapping:* Resident, $2; nonresident, British subject, $25; other nonresident, $50. *Fur dealer,* $5; issued by Commissioner of Dominion Parks. License not required of native-born resident Indian, Eskimo, or half-breed.

Possession and sale: Licensed trapper may sell or trade the skins of animals he has legally taken. Possession of unprime or low-grade furs prohibited. No restrictions on other skins legally taken.

Shipment and export: No restrictions on skins legally taken and possessed.

Propagation: Permits may be obtained to take fur animals for propagation.

Bounties: Timber wolf, $20.

NOVA SCOTIA.

Open seasons:[1]	*Dates inclusive.*
Beaver, marten	No open season.
Bear, wolf, wildcat	Unprotected.
Other fur animals	Nov. 1-Jan. 31.

Prohibited methods: Unlawful to take any protected fur animal (unless under a permit) from a burrow or den by smoking, digging, or otherwise; to take fur animal by use of poison; to damage or molest a beaver dam or house or a muskrat house or to set snare or trap within 25 feet of the latter.

Licenses: *Trapping:* None required of resident; nonresident, $30; issued by Provincial secretary, game commissioners, and county clerks. *Fur buyers*: Nonresident, $25; resident, $2; issued by chief game commissioner. Fur buyer must keep record and make monthly report of number of skins bought or sold, together with names and addresses of parties from whom purchased or to whom sold.

Possession and sale: Unlawful to possess or sell the green hide of any beaver or marten, or to possess the green hide of any fur animal taken out of season. No other restrictions on skins legally taken.

Shipment and export: Unlawful to export skins of fur animals except under certificate of inspection and permit (fee, 50 cents) from a game official (postmaster).

Propagation: Permits (fee, $1) to take wild animals may be obtained from the board of game commissioners under such restrictions as they may require. Unlawful to keep fur-bearing animals in captivity for breeding purposes without a permit from the chief game commissioner; fee, $2 for each kind of animal kept, payable annually. Reports are required annually on September 30. Unlawful to trespass in inclosures for fur animals.

Bounties: None paid.

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[97] *New Brunswick:* License requirements and other provisions of act do not apply to a hunter or trapper who is a British subject domiciled and residing in Province, who actually hunts, provided he sells his furs to a person domiciled in the Province.

[98] "*Northwest Territories*" means the northwest territories formerly known as Rupert's Land and the Northwestern Territory (except such portions thereof as are included in the Provinces of Ontario, Quebec, Manitoba, Saskatchewan, and Alberta, and the Yukon Territory), together with all British territories and possessions in North America and all islands adjacent thereto not included within any Province, except the Colony of Newfoundland and its dependencies.

[99] All trapping prohibited on Victoria and Banks Islands.

[1] *Nova Scotia:* Fox, raccoon, skunk, weasel, or muskrat may be killed on one's own inclosed premises for the protection of private property.

ONTARIO.

Open seasons:	*Dates inclusive.*
Mink, fisher, marten	Nov. 1-Apr. 30.
Muskrat (see exception)	Apr. 1-May 20.
Exception: South of French and Mattawa Rivers	Mar. 1-Apr. 20.
Beaver, otter	Nov. 1-Mar. 31.[1]
Other fur animals	Unprotected.

Prohibited methods: Unlawful to shoot or spear muskrats or, except when they are destroying property, to injure their houses.

Licenses: Resident, $5; nonresident, $50; issued by Department of Game and Fisheries. Nonresident not permitted to take beaver or otter. Beaver and otter skins must bear prescribed coupons (fee, series of 5, $2.50—trapper limited to 10 coupons for beaver and otter a season). License not required to take wolf or fox. Farmers and their sons may trap on own land during open season without license, except that a $1 license is necessary to trap beaver or otter thereon. Permission of owner required to trap beaver on lands of another. Treaty Indian living north and west of French and Mattawa Rivers and Lake Nipissing and holding annual certificate from Department of Indian Affairs not required to obtain trapping license, but is limited to 10 beaver or otter a season, the skins of which may only be sold to persons licensed to issue coupons. Treaty Indian must produce his certificate to buyer and have indorsed thereon the number and kind of skins bought, numbers of the coupons attached thereto, and return certificate to Department of Indian Affairs. Fur dealers or traders: resident British subject, $10; alien, $25; licensee must make monthly reports. Fur dressing and tanning, $10; licensee must keep records and make monthly reports.

Possession and sale: Possession of furs during close season prohibited except under permit. Possession and sale of unprime skins prohibited, except under permit. Unlawful for trapper or farmer to sell beaver or otter skins except to a licensed dealer, from whom he must secure a receipt showing number of pelts, numbers of coupons attached, and number of dealer's license, which receipt must be forwarded to the Department of Game and Fisheries. Unlawful to have skins dressed, plucked, or treated in any way except under permit obtained upon payment of royalties.

Shipment and export: Export prohibited except under permit obtained upon payment of royalties. No other restrictions on skins legally taken, possessed, or tagged.

Propagation: A permit is required of breeders of game or fur animals. Licensed fur breeders may sell live animals or skins during open season upon payment of royalties. The minister may grant permits to take fur animals during the close season for propagating and scientific purposes.

Bounties: Gray timber wolf, $20; other wolf, $5; paid by county, but Provincial treasurer refunds 40 per cent to county. Provincial treasurer pays entire bounty in unorganized counties.

PRINCE EDWARD ISLAND.

Open seasons:	*Dates inclusive.*
Otter, marten, mink, muskrat	Nov. 1-Mar. 31.
Beaver	No open season.[2]
Other fur animals	Unprotected.

Prohibited methods: Unlawful to put out poisoned baits for fox or other animals.

Licenses: None required of resident; nonresident, $50; issued by secretary-treasurer of Province. The game warden may grant permits to take beaver and issue coupons (fee, $1 each) to tag skins of animals taken.

Possession and sale: Possession and sale during close season prohibited. Holders of permits may possess, buy, or sell beaver skins which have proper coupons attached.

Shipment and export: No restrictions on animals legally taken, possessed, and tagged.

Propagation: Several special acts of the Provincial legislature regulate fox ranching on the Island. The animals are assessed for taxation, ranches are protected from trespass under heavy penalties, and incomes from ranches are taxed.

Bounties: None paid.

QUEBEC.

Open seasons:	*Dates inclusive.*
Bear	Aug. 20-June 30.
Muskrat (see exception)	Nov. 1-May 31.
Exception: South of 50th parallel	Nov. 1-Apr. 30.
Fox	Nov. 1-Feb. 28.
Other fur animals	Nov. 1-Mar. 31.

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[1] *Ontario:* Beaver and otter may be taken by residents only. Not more than four beaver may be taken from a family or colony. Beaver, when damaging property, may be destroyed by game overseer under special authorization from the department of game and fisheries.

[2] *Prince Edward Island:* Beaver may be taken under special license. They may be destroyed by the owner of private property on which they are locating or building dams, and, under permit from game warden or lieutenant governor in council, their dams may be destroyed when necessary to prevent damage to property.

Prohibited methods: Use of poisons in taking fur animals prohibited.

Licenses: *Trappers*[4] *and fur dealers:* Persons domiciled in Province, $10; all other persons $50; issued by minister of fisheries and game. Trappers[4] and fur dealers must furnish the minister with written declarations showing their names and addresses, location of warehouses, shops, posts, or caches where skins are to be stored, and the places from which such furs will be shipped out of the Province.

Possession and sale: Persons engaged in buying, selling, or taking fur animals must, on or before the 10th of each month, make report to the minister of fisheries and game. Unlawful to possess, buy, or sell skins of fur animals on which royalty has not been paid. No other restrictions on skins legally taken.

Shipment and export: Shipment and export prohibited, except of fur animals or furs on which royalties have been paid. Skins must be shipped open to view and each skin must be stamped to show royalty paid and be tagged as prescribed by the minister before being shipped in any manner. Packages muse show names and addresses of consignor and consignee.

Propagation: The minister of colonization, mines, and fisheries may grant permits to take animals alive for breeding purposes; nonresident license fee, from $5 to $25.

Bounties: Wolf, $15.

SASKATCHEWAN.

Open seasons:[5]	*Dates inclusive.*
Beaver	Dec. 1–Apr. 30.[6]
Mink, fisher, marten, fox (see exception)	Nov. 1–Mar. 31.
Exception: Fox, south of Township 51	Unprotected.
Otter	Nov. 1–Apr. 30.
Muskrat:[7]	
North of Township 52 (also Nov. 1 to Nov. 30)	Mar. 1–May 14.
South of Township 53	Mar. 1–Apr. 30.
Other fur animals	Unprotected.

Prohibited methods: Unlawful to use poison to take fur animals, to spear or shoot beaver or muskrat, or to destroy muskrat houses.

Licenses: Resident, $2; nonresident, $25; resident licensee must return license on or before May 31 to chief game guardian with statement showing number of each kind of fur animals taken by him. Fur dealer, resident, north of Township 25, $10; south of Township 26, $2; traveling agent for resident dealer, $10; nonresident or his traveling agent, $20; taxidermist, $5; licensee must keep duplicate receipt book and furnish a copy thereof every 3 months to the minister. Issued by Department of Agriculture, Regina. Licensed fur trader must make annual report of operations. Resident treaty Indians may trap during open season without a license. Consent of owner or occupant required to trap on inclosed or cultivated lands of another. No license issued to person under 16 years of age without written consent of parent or guardian.

Possession and sale: Unlawful to buy, sell, or possess unprime furs, except those of wolf or coyote. No other restrictions on skins legally taken.

Shipment and export: Packages containing fur animals must be plainly marked with full description of contents and names and addresses of consignor and consignee. Export of live fur animals prohibited except under permit of minister; fees, for black or silver fox, $25; for cross or red fox or other live fur animal, $5. Unlawful to ship unprime furs except wolf or coyote. No other restrictions on skins legally taken.

Propagation: Permit required (fee, $1 annually) to operate a fur ranch. Permit to ship live fur animals is required; fee, for black or silver fox, $25; for cross or red fox or other fur animal, $5. Young foxes may not be taken from dens before May 15.

Bounties: Adult timber wolf, $10; pups of prairie or timber wolf, $1; paid only in properly gazetted wolf districts, when half is refunded from Provincial treasury.

YUKON.

Open seasons:[8]	*Dates inclusive.*
Lynx, marten, mink, otter	Nov. 15–Apr. 1.
Muskrat	Dec. 1–June 1.
Beaver	No open season.[9]
Other fur animals (see exception)	Unprotected.
Exception: Fox (under 1 year of age)	June 1–Mar. 31.

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[4] *Quebec:* The act does not apply to a hunter or trapper who actually hunts, if he is domiciled and resides in the Province, and is a British subject.

[5] *Saskatchewan:* Trapping on game preserves prohibited.

[6] Beaver are protected on game preserves and may be protected in any municipality upon recommendation of the council and proclamation of minister.

[7] Minister may authorize the council of any municipality to destroy muskrats doing damage to highways or other public improvements.

[8] *Yukon:* Commissioner in council may alter seasons.

[9] Expires Nov. 1, 1923.

Prohibited methods: Use of poison prohibited.

Licenses: None required of resident; nonresident, $100. Fur buyer or dealer (purchasing furs for sale or export): Nonresident, $150; resident, $25; mercantile establishment buying furs, $10 (required for each place of business other than head office); issued by gold commissioner or person designated by him.

Possession and sale: Skins legally taken may be possessed and sold at any time.

Shipment and export: Export of raw furs prohibited except under permit issued by direction of the commissioner, and upon payment of the export tax. Export of live fox prohibited. (*See* Propagation).

Propagation: Registration of fox breeders required. Unlawful to export a fox not born in captivity or which has been in captivity for less than a year; any fox born in captivity may be exported under a permit (fee, $5). Fox and other fur ranches, if posted against tresspass, may not be approached without owner's consent. No restrictions on other fur animals.

Bounties: None paid.

LAWS OF NEWFOUNDLAND.

(1920 laws not received.)

Open seasons:[10]	*Dates inclusive.*
Otter, marten, lynx	Oct. 1–Mar. 31.
Fox	Oct. 16–Mar. 14.
Muskrat	Oct. 1–Apr. 30
Beaver	No open season.[11]

Prohibited methods: No restrictions.

Licenses: None required of resident; nonresident, $501; issued by justice. Fur buyers and shippers, 50 cents; issued by game and inland fisheries board. Licensed fur buyer must report operations before December 31 of each year.

Possession and sale: No restrictions on skins legally taken.

Shipment and export: (*See* Licenses.) Unlawful to export live fox unless raised in captivity. No other restrictions on skins legally taken.

Propagation: No restrictions, except as to fox. A fox farm must be licensed; the owner must at stated times make reports to the game and inland fisheries board, and the premises must be at all times open to inspection by officers of the board. Possession of fox cub or fox taken in close season is prohibited. Unlawful to export a fox not bred on a fox farm, or, without permit from the colonial board, to export a fox bred in captivity.

Bounties: Crow, 20 cents.

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[10] *Newfoundland:* Unlawful to trap on Grand Lake Caribou Preserves.

[11] Expires Oct. 1, 1920.

OFFICIALS FROM WHOM COPIES OF LAWS RELATING TO FUR-BEARING ANIMALS MAY BE OBTAINED.

Alabama: Department of conservation, Montgomery.

Alaska: Secretary of Agriculture, Washington, D. C. See footnote 5, p. 7.

Arizona: State game warden, Phoenix.

Arkansas: Secretary, game and fish commission, Little Rock.

California: Executive officer, fish and game commission, Postal Telegraph Building, San Francisco.

Colorado: State game and fish commissioner, Denver.

Connecticut: Secretary, commission of fisheries and game, Hartford.

Delaware: Chief game warden, Dover.

District of Columbia: Superintendent metropolitan police, Washington.

Florida: Secretary of state, Tallahassee.

Georgia: Game and fish commissioner, Atlanta.

Idaho: Fish and game warden, Boise.

Illinois: Chief game and fish warden, Springfield.

Indiana: Superintendent, division of fisheries and game, State House, Indianapolis.

Iowa: State fish and game warden, Lansing.

Kansas: State fish and game warden, Pratt.

Kentucky: Executive agent, game and fish commission, Frankfort.

Louisiana: Commissioner of conservation, Court Building, New Orleans.

Maine: Commissioner of inland fisheries and game, Augusta.

Maryland: State game warden, 512 Munsey Building, Baltimore.

Massachusetts: Director, division of fisheries and game, State House, Boston.

Michigan: Commissioner game, fish, and forest-fire department, Lansing.

Minnesota: Game and fish commissioner, St. Paul.

Mississippi: Secretary of state, Jackson.

Missouri: Game and fish commissioner, Jefferson City.

Montana: State game warden, Helena.

Nebraska: Chief deputy, game and fish commission, Lincoln.

Nevada: State fish and game warden, Carson City.

New Hampshire: Fish and game commissioner, Sunapee.

New Jersey: Secretary, board of fish and game commissioners, Trenton.

New Mexico: Game and fish warden, Santa Fe.

New York: Secretary, conservation commission, Albany.

North Carolina: Secretary, Audubon Society of North Carolina, Raleigh.

North Dakota: Secretary, game and fish board, Steele.

Ohio: Chief game warden, board of agriculture, Columbus.

Oklahoma: State game warden, Oklahoma City.

Oregon: State game warden, Portland.

Pennsylvania: Secretary, board of game commissioners, Harrisburg.

Rhode Island: Chairman, commissioners of birds, Providence.

South Carolina: Chief game warden, Columbia.

South Dakota: State game warden, Pierre.

Tennessee: State game and fish warden, Nashville.

Texas: Game, fish, and oyster commissioner, Austin.

Utah: Fish and game commissioner, Salt Lake City.

Vermont: Fish and game commissioner, Montpelier.

Virginia: Commissioner of game amd inland fisheries, Richmond.

Washington: Chief game warden and State fish commissioner, Seattle; chief deputy game warden, Yakima.

West Virginia: Forest, game, and fish warden, Elkins.

Wisconsin: Secretary, conservation commission, Madison.

Wyoming: State game warden, Cheyenne.

Alberta: Chief game guardian, Edmonton.

British Columbia: Secretary, game conservation board, Vancouver.

Manitoba: Chief game guardian, Winnipeg.

New Brunswick: Chief game and fire warden, Fredericton.

Northwest Territories: Commissioner, Dominion Parks Branch, Ottawa.

Nova Scotia: Chief game commissioner, Halifax.

Ontario: Superintendent, game and fisheries, Toronto.

Prince Edward Island: Game inspectors (county sheriffs).

Quebec: General inspector, fisheries and game, Quebec.

Saskatchewan: Chief game guardian, Regina.

Yukon: Gold commissioner, Dawson.

Colony of Newfoundland: Secretary, game and inland fisheries board, St. Johns.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO FUR-BEARING ANIMALS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

The Common Mole of Eastern United States. (Farmers' Bulletin 583.)
Economic Value of North American Skunks. (Farmers' Bulletin 587.)
The Domesticated Silver Fox. (Farmers' Bulleton 795.)
Trapping Moles and Utilizing Their Skins. (Farmers' Bulletin 832.)
The Muskrat as a Fur Bearer. (Farmers' Bulletin 869.)
Rabbit Raising. (Farmers' Bulletin 1090.)
Game Laws for 1920. (Farmers' Bulletin 1138.)
Fur Farming as a Side Line. (Yearbook Separate 693.)
Trapping on the Farm. (Yearbook Separate 823.)
Annual Report of the Governor of Alaska on the Alaska Game Law, 1919. (Department Circular 88.)
Directory of Officials and Organizations Concerned with the Protection of Birds and Game, 1920. (Department Circular 131.)
Maintenance of the Fur Supply. (Department Circular 135, in press.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Deer Farming in the United States. (Farmers' Bulletin 330.) Price, 5 cents.
The Muskrat. (Farmers' Bulletin 396). Price, 5 cents.
Raising Deer and Other Large Game Animals in the United States. (Biological Survey Bulletin 36.) Price, 15 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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POISON IVY AND POISON SUMAC AND THEIR ERADICATION

C. V. GRANT
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and
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Office of Forage-Crop Investigations

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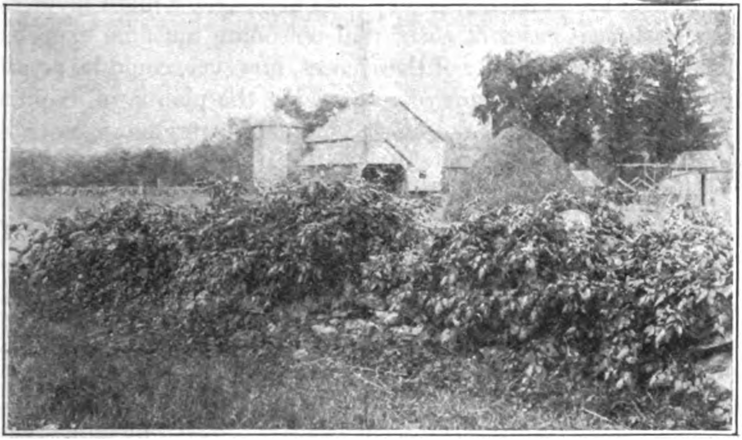

FARMERS' BULLETIN 1166

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. October, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

MANY PERSONS obtain their first acquaintance with poison ivy or its relative, poison sumac, by being painfully poisoned, sometimes as the result of collecting the foliage of these plants for ornamental purposes, despite the fact that it is generally known that contact with them may produce severe inflammation of the skin.

In many localities throughout the country poison-ivy growth is so abundant as to discourage attempts to destroy it in order to reduce the danger of injury, and even under more favorable circumstances cases of accidental poisoning must be expected. The very large number of these cases, however, could be greatly reduced if simple means of recognizing the plants, of avoiding poisoning by them, and of destroying them were more generally understood.

As a preventive measure, thorough washing is recommended, since the poison usually requires some time to penetrate into the tender layers of the skin, and until such penetration has taken place much or all of it can be removed. Ordinary alkaline kitchen soap is best for this purpose. A thick lather should be produced and the washing repeated several times, with thorough rinsing and frequent changes of hot water.

The methods of destroying poison-ivy growth include spraying with salt brine (3 pounds of salt to the gallon of water) repeated several times if found necessary at intervals of a week or two, pulling by hand or grubbing out small areas, frequent mowing, and, in fields, plowing followed by the cultivation of hoed crops.

Poison sumac usually occurs in swampy inaccessible locations where the expense of eradication is not warranted. When it grows along the edges of paths or roads or in frequented places it should be cut off close to the ground, after which the roots should be grubbed out or killed by applying salt, crude oil, or chemicals to the newly cut surfaces and the surrounding soil.

POISON IVY AND POISON SUMAC AND THEIR ERADICATION.[1]

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IVY AND SUMAC POISONING LARGELY PREVENTABLE.

ALTHOUGH it is generally known that contact with poison ivy and poison sumac may cause painful inflammation of the skin, many persons are poisoned because they do not know how to recognize and avoid these plants. Much injury is caused by permitting poison ivy to spread year after year along roadways and much-used paths, frequently in small patches that could be destroyed with comparatively little effort or expense. Accidental cases of ivy and sumac poisoning are to be expected, but the very large number of these cases could be greatly reduced if simple means of detecting and dealing with the plants and of preventing their poisonous effects were more generally understood.

THE POISON-IVY PLANT.

The poison-ivy plant is also known as poison oak and by various local names, such as three-leaved ivy, poison creeper, climbing sumac, markweed, picry, and mercury. It grows in the form of woody vines, trailing shrubs, or low erect bushes and adapts itself to the greatest variety of conditions, flourishing in woods or in the open, in low moist soil or in dry soil, and on hillsides. It is especially abundant along fence rows and at the edges of paths and roadways, scrambling over rocks and walls, climbing posts or trees to considerable heights, often mixed with other shrubbery in such a way as to escape notice until attention is attracted to it by the occurrence of cases of poisoning.

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[1] The Public Health Service has recently issued a general summary of the available information on this subject in an article under the title "Ivy and Sumac Poisoning," by E. A. Sweet and C. V. Grant, prepared in collaboration between that service and the United States Department of Agriculture and published in Public Health Reports, vol. 35, pp. 435–458, Feb. 27, 1920. As the edition of the report specified was limited it has been found desirable to make the information available for further distribution in the form of the present bulletin, which is based largely upon the article mentioned. The methods of eradication herein suggested were developed as the result of experiments carried on by the Office of Forage-Crop Investigations.

Poison ivy, or poison oak, is found in one or more forms in practically all sections of the country. The various forms, while they include several distinct botanical species, differ mainly in the shape and margins of the leaflets, the size of the fruit, and the habit of growth and are so much alike in general character that familiarity with any one form will make it possible to recognize the plants wherever encountered, whether as vines or shrubs, or at least to avoid all plants bearing a suspicious resemblance to them.

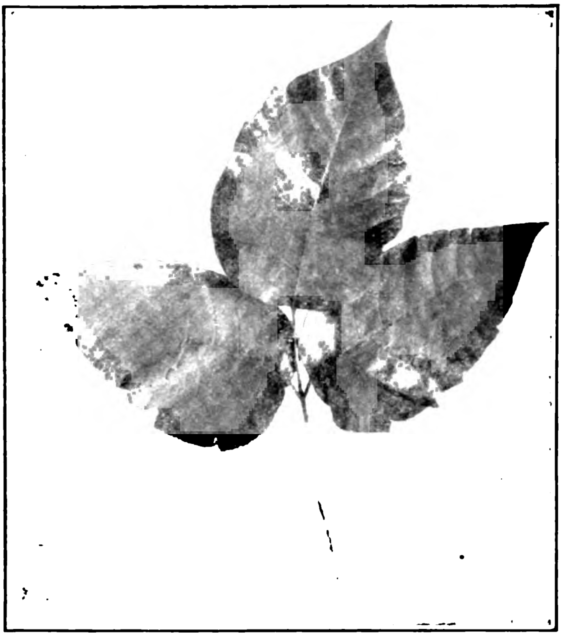

FIG. 1.—Leaf of poison ivy (*Rhus radicans* L.). The poison-ivy leaf is always divided into three leaflets.

HOW TO DETECT POISON IVY.

The plants are most readily recognized by their leaves, which are always divided into three leaflets in the manner shown in figure 1, and by their whitish waxy fruits, which look somewhat like mistletoe berries, each containing a single stony seed. The homely saying "Leaflets three, let it be" offers a measure of safety to those who are unacquainted with poison ivy, even though it may occasionally lead to undue suspicion and the avoidance of some innocent or harmless plant. The plants do not all bear fruits but, when discovered, the whitish or cream-colored berries (more correctly called drupes), shown on the fruiting specimen in figure 2, make recognition positive. These remain far into the winter and thus point out the plants long after there leaves have fallen.

DESCRIPTION OF THE PLANTS OF POISON IVY.

The vines will be found spreading by underground root stems and sending up an abundant shrubby growth, the branches of which show a tendency to ascend any convenient support, attaching themselves by means of masses of the small rootlets illustrated in figure 2, but lacking the twining tendrils found on many climbers.

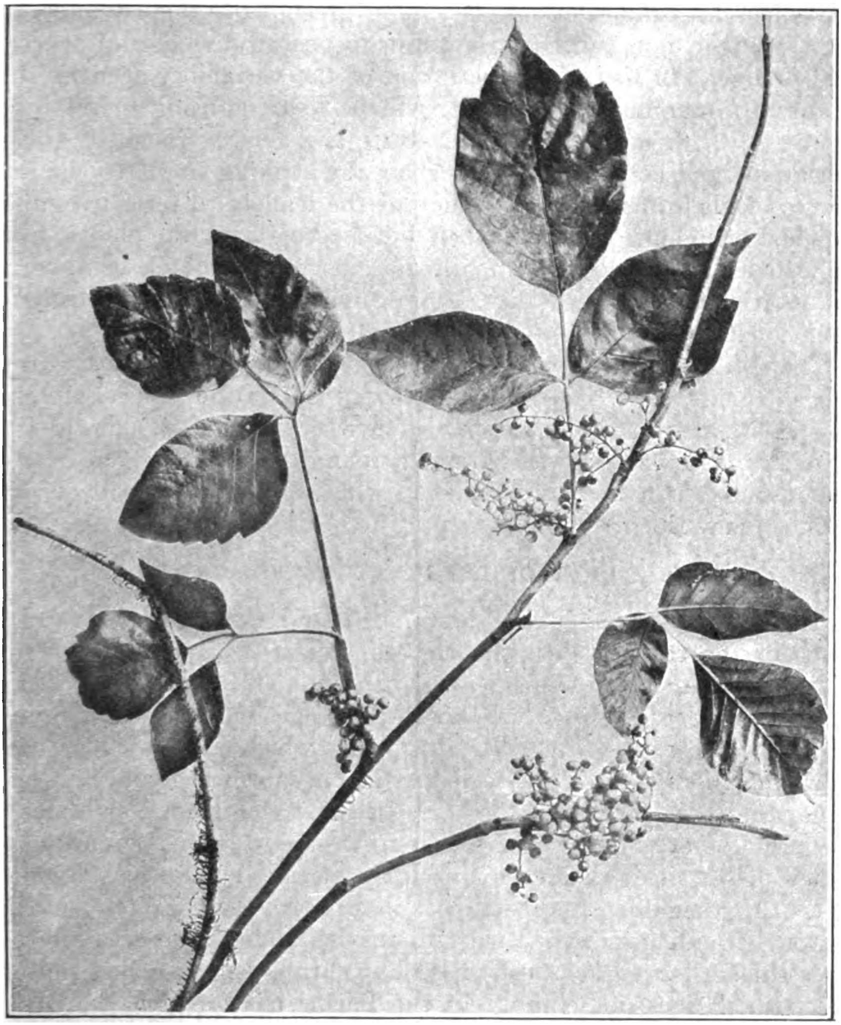

FIG. 2.—Poison ivy (*Rhus radicans* L.). Branches of the poison-ivy vine, showing the leaves, fruit, and aerial rootlets.

The erect bushes or trailing shrubs attain a height varying from a few inches to about 3 feet, but in favorable situations may make a luxuriant bushy growth 4 or 5 feet high.

The leaves of all forms have stout, rather long stalks, bearing three leaflets, two of which are opposite and short stalked, while the end leaflet is long stalked. The leaflets vary from 1 to 4 inches in length and when mature are dark green on the upper surface, lighter and sometimes velvety underneath. The crinkly young leaves are red when they first unfold, becoming green with the advance of mild weather, and turning in autumn to beautiful shades of scarlet and orange. In lieu of a description of the variability seen in the shape and margins of leaflets, it will be less confusing to refer to figures 1, 2, 3, and 4, which illustrate the general range of these variations and at the same time show the striking similarity in the leaves of all forms. The tendency of the leaflets to form irregular notched or indented margins is an aid in recognizing the plants, and in leaflets with generally smooth margins a deep notch or several indentations on the side (figs. 1 and 2) will often serve to confirm their identification as poison ivy.

The small 5-petaled yellowish green flowers appear in early summer in clusters 1 to 3 inches long, growing out of the angles between the leafstalk and the plant stem or above scars along the sides of the branches, and are followed by small, roundish, smooth green fruits, about one-fourth inch in diameter, which become white or ivory color as they ripen.

LOCAL FORMS OF THE PLANTS OF POISON IVY.

The forms[2] in which the plants are found vary in different sections of the country. In the eastern and central portions of the United States are found poison-ivy vines, trailing shrubs, and bushes with leaves similar to those of the specimen shown in figure 2;[3] also a low, erect, small-fruited bush, which in many localities in the northern part of this region is the only form seen and is sometimes called northern poison oak.[4] In the region from New Jersey, Delaware, and Virginia south and southwestward there is found a so-called poison oak [5] that does not climb, bearing leaflets as shown in figure 3, resembling those of certain eastern oaks. West of this region, extending into the Rocky Mountains, these forms are replaced by a thicker leaved low bush or trailing shrub, usually called poison oak,[6] which does not climb. In the Pacific coast region the plant generally known as poison oak[7] occurs as a bush, with leaflets as shown in figure 4, resembling the leaves of western oaks, but it is also found as a vine and is sometimes called poison ivy or yeara.

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[2] Poison ivy and poison sumac comprise a toxic group which has generally been placed by botanical authors under the genus Rhus. By some botanical authors they are grouped under the generic name Toxicodendron.

[3] *Rhus radicans* L.

[4] *Rhus microcarpa* (Michx.) Steud. By some authors considered only a form of *Rhus radicans*.

[5] *Rhus quercifolia* (Michx.) Steud. The name *Rhus toxicodendron* has been applied to this plant by some authors, but is generally considered to refer to the poison-ivy vine (*Rhus radicans*).

[6] *Rhus rydbergii* Small. By some authors this is considered only a low form of *Rhus radicans*.

[7] *Rhus diversiloba* Torr. and Gray.

It may be noted that in various localities the plants with leaflets resembling certain kinds of oak foliage, including certain forms that do not climb, are sometimes called poison oak. This name is often used to distinguish such forms from poison-ivy vines. As climbing forms are found with oak-leaved foliage and leaflets of the poison-ivy vine forms are frequently more or less lobed like oak leaves, efforts to make this distinction between poison ivy and poison oak are confusing, and many persons use either name for all forms of the plants.

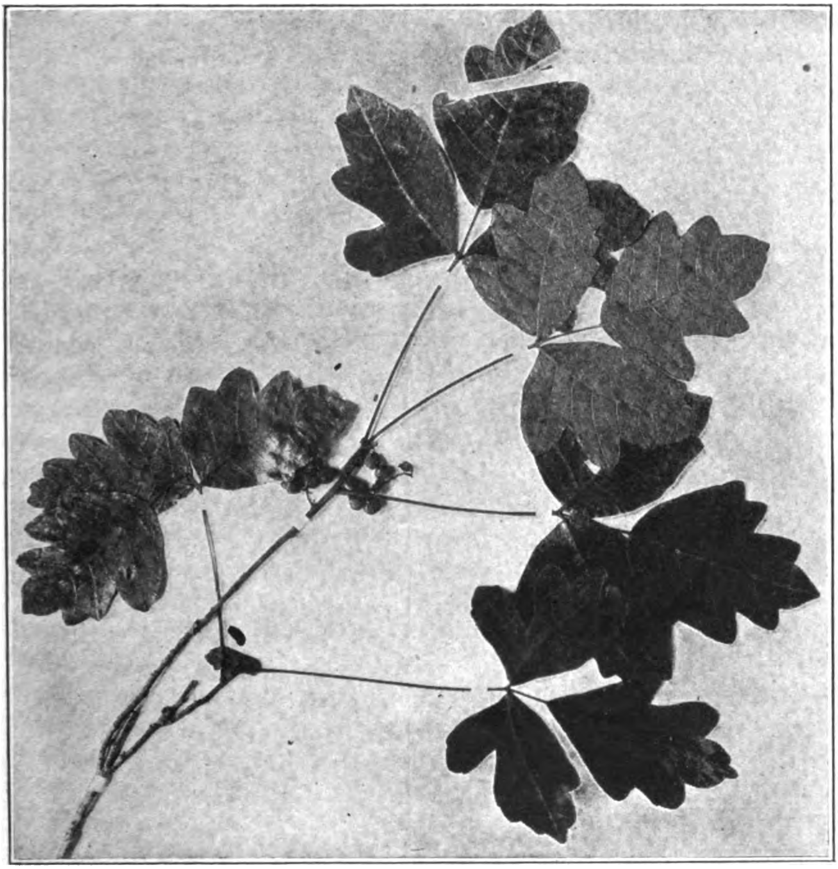

FIG. 3.—Poison oak (*Rhus quercifolia* (Michx.) Steud.) of the eastern United States.

CONFUSION OF POISON IVY WITH THE VIRGINIA CREEPER.

In the Eastern States and westward as far as Wyoming to Texas, the Virginia creeper[8] is found generally in the same locations as poison-ivy vines, often mixing with the ivy growth, which it resembles in its climbing habit and in the shape of its leaflets. In this way it is sometimes confused with poison ivy, but it is harmless to the touch and is readily distinguished by its leaves, which generally bear five leaflets to a stalk, as shown in figure 5. It climbs partly by aerial rootlets, like those of poison ivy, but also has numerous tendrils, like those of grapevines, and it has red-stemmed blue fruits, each containing two or three seeds.

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[8] *Parthenocissus quinquefolia* (L.) Planch.

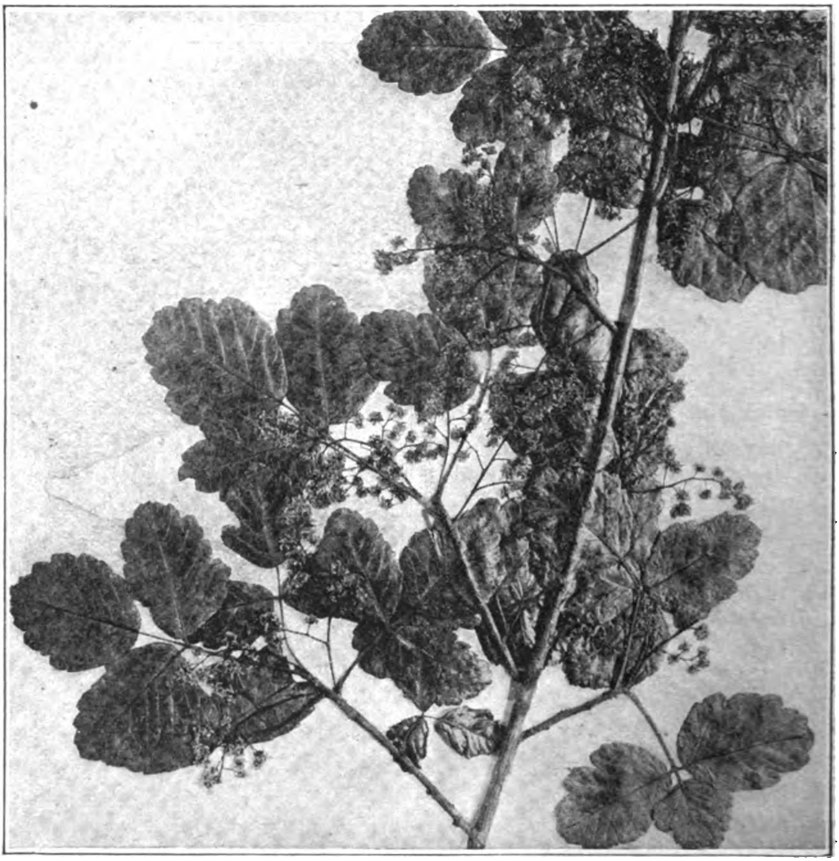

FIG. 4.—Poison oak (*Rhus diversiloba* Torr. and Gray) of California and the Pacific coast. Portion of the branch in flower.

THE POISON-SUMAC PLANT.

Poison sumac[9] is also known as swamp sumac, poison elder, poison ash, poison dogwood, and thunderwood. It grows only in swamps or in wet ground. It is found from the New England States south as far as Florida and westward to Minnesota, Arkansas, and Louisiana. It grows as a shrub in clumps, with tall slender

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[1] *Rhus vernix* L.

stems 6 to 10 feet or more in height; also frequently as a tree up to 20 or 30 feet high, with a trunk 5 to 10 inches in diameter.

HOW TO DETECT POISON SUMAC.

The leaves of poison sumac are divided into 7 to 13 leaflets, arranged in pairs with a single leaflet at the end, as shown in figure 6. The avoidance of shrubs growing in low land with leaves of this general character is a safe rule for persons not well acquainted with poison sumac, although it may lead to needless avoidance of some harmless plants. The cream-colored fruits of poison sumac, resembling those of poison ivy but growing in looser clusters, 3 to 8 inches long, remain through the winter and make recognition positive. Poison sumac grows only on wet land, but sometimes occurs in unsuspected places along roadways at the edges of swamps or along low, miry banks of streams.

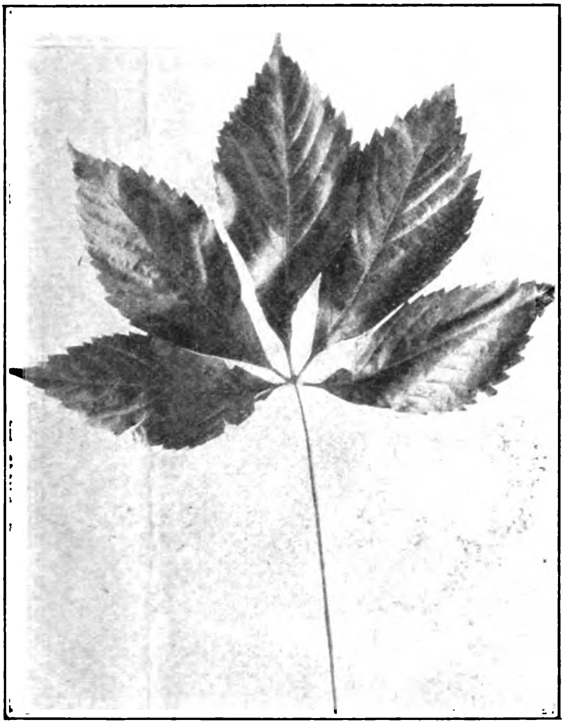

FIG. 5.—Leaf of Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.). Note that the leaf is divided into five leaflets.

DESCRIPTION OF POISON SUMAC.

The poison-sumac bush or tree has smooth grayish bark on the trunk and older branches, while the young new branches are reddish brown. The leaves vary from 7 to 14 inches in length and consist of a clean stalk bearing 7 to 13 leaflets, arranged opposite one another in pairs, with a single, usually long-stalked leaflet at the end. The leaflets, which are of an elongated oval shape with whole margins, grow from 3 to 4 inches long and 1½ to 2 inches wide. They are velvety and of a bright-orange color when they first appear in the spring, later becoming dark green and glossy on the upper surface, with prominent scarlet midribs, and paler green underneath. They turn early in autumn to brilliant red, orange, and russet shades. The small 5-petaled yellowish green flowers appear early in summer in loose slender clusters about 3 to 8 inches long, growing out of the angles of the leafstalks near the ends of the branches. They are followed by shining ivory-white or cream-colored fruits, resembling those of poison ivy, about one-fourth inch in diameter, each containing a single stone.

CONFUSION OF POISON SUMAC WITH HARMLESS SUMAC AND OTHER PLANTS.

As suggested by the names applied to it, poison sumac is often confused with elder, certain kinds of ash, and various other shrubs and trees bearing somewhat similar foliage; also with dogwood to which it bears no resemblance. It is at once excluded from plants growing in high, dry locations, though it is sometimes found at the edges of swamps and bogs or where the ground is somewhat dry during part of the year. Its loose, drooping clusters of flowers, followed by smooth ivory-white fruits, are readily distinguished from the densely covered upright terminal spikes of the harmless sumacs (conspicuously red in the fruiting stage) and from those of other shrubs with which it is confused. The leaflets, 7 to 13 in number, are borne on

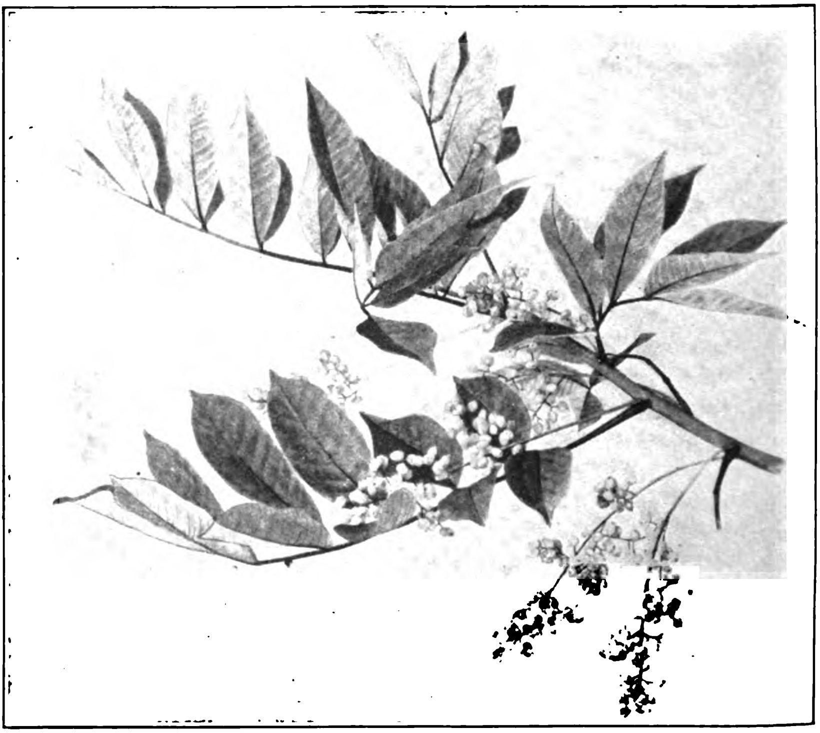

FIG. 6.—Poison sumac (*Rhus vernix* L.). From a water color by F. A. Walpole.

plain round stalks and have a tendency to fold forward in the manner shown in figure 6. In the harmless sumacs the leaves bear 9 to 21 leaflets, or 31 leaflets in the commoner species. Other differences are readily noticed, such as the winglike growth along the margins of the leafstalks of the dwarf sumac and the hairy coverings of the leafstalks and twigs of the staghorn sumac.

POISONOUS ACTION OF POISON IVY AND POISON SUMAC.

Poison ivy and poison sumac are close relatives and are alike in their poisonous properties. Their poisonous principle is a nonvolatile oily substance known as toxicodendrol, which has such violently irritant properties that the slightest trace deposited on the skin is capable of producing severe inflammation. All parts of the plant contain the poison, even after long drying, but growth in which the sap is abundant is the most dangerous.

Poisoning is usually caused by touching or brushing against the plants or by handling clothing or other articles which have been in contact with them. On the other hand, many persons are convinced that they have been poisoned in passing by the plants or observing them from a short distance, without actually touching them, by particles carried through the air. There is much difference of opinion and conflicting evidence on this point. Many sensitive individuals find that they are fully protected by avoiding actual contact with the plants or with articles contaminated with the poison. It is well known, however, that smoke from the burning plants will carry the poison and may cause serious injury.

Many persons believe themselves immune to ivy poison and seem to be able to handle the plants freely without being harmed. Experience and experiments seem to show, however, that complete immunity to ivy poisoning does not exist, and many supposedly immune persons have not only been poisoned by carelessly handling the plants, but afterwards have suffered attacks on the slightest exposure.

Taken internally in sufficient dose the plant is a violent irritant poison. Cases of children who have been poisoned by eating the ripe fruits have been reported.

The symptoms of ivy poisoning are produced as the irritant poison penetrates the outer surface of the skin, and they may appear within a few hours or be delayed until five days or longer after exposure. Itching or burning sensations, with reddening of the poisoned surfaces and more or less swelling, are first noticed, usually followed by the appearance of small vesicles, which may show a tendency to run together and form blisters. Pus may form in these vesicles, followed by a crust or scab formation as the eruption dries. The acute symptoms of the attack usually continue to develop for a day or two, followed by gradual improvement as the effects of the irritant wear off.

PREVENTION OF IVY POISONING.

Those who are sensitive to ivy poisoning should not only avoid touching the plants, but also should use care in handling articles which may have been in contact with them. Contaminated shoes, clothing, or tools are sources of poisoning sometimes overlooked, as are also animals that have access to poison-ivy patches.

While the plants are sometimes so abundant as to make complete eradication practically impossible, the destruction at least of smaller areas, especially along paths and in frequented situations, should be undertaken.

After exposure to poison ivy, measures to insure the removal of the poison are of primary importance. It should be remembered that at first the poison is on the surface of the skin and can be removed by thorough washing and rinsing repeated several times. Careless washing, however, may serve to spread the poison. Ordinary kitchen or laundry soap which has an excess of alkali is best for the purpose, and hot water should be used. The soap should be used freely, so as to produce an abundant heavy lather on the exposed surfaces, then rinsed off completely, and the operation repeated not less than three or four times. Running water is preferable, or, if a basin is used, the water should be changed frequently. The hands, especially the finger nails, should receive particular attention, in order to remove traces of the poison which they may harbor and transfer to other parts of the body. Hard scrubbing with a stiff brush is not advised, as it may serve to rub in the poison and stir up infection, but there is no objection to wash rags, provided several are used and each discarded in turn. The poison can also be removed by cleansing the exposed parts repeatedly with alcohol diluted with an equal quantity of water. Alcohol merely dissolves the poison and unless applied with caution, insuring its complete removal, will spread it over wider areas. The alcohol may be dabbed on with a piece of absorbent cotton, promptly removing it with a dry piece, discarding each piece of cotton as used and repeating the procedure a number of times.

REMEDIES FOR IVY POISONING.

Mild cases of ivy poisoning generally subside within a few days and do not cause alarm, but fatal cases have occurred. When the inflammation is extensive or severe, a physician should be consulted. Since the inflammation may continue to develop for several days, while the irritant is being slowly absorbed into the tender layers of the skin, it is not surprising that remedies tried in the early stages may prove disappointing or that if they are discarded in favor of some other remedy just as the poison becomes exhausted the rapid improvement which is then noted may cause the last remedy to be regarded as a sure cure.

Thorough washing, in the manner described as a preventive, should be tried even after the inflammation has developed, in order to remove from exposed surfaces of the skin all traces of the poison that can still be reached.

For the inflammation, simple remedies, such as local applications of solutions of cooking soda or of Epsom salts, one or two heaping teaspoons to a cup of water, are generally as helpful as any. Fluid extract of grindelia, diluted with 4 to 8 parts of water, is often used. Solutions of this kind may be applied with light bandages or clean cloths, which should be kept moist and should also be changed and discarded frequently in order to avoid infection. During the night, or when moist applications can not be used, the poisoned surfaces should be carefully cleaned and dried and left exposed to the air rather than tightly bandaged. Immersing the poisoned parts for several minutes in water as hot as can be borne or applying hot towels where this is impracticable is much recommended for the itching. This measure increases the discomfort at the moment of application, but it is followed by a period of great relief. In the early stages remedies with a fatty or oily base, such as ointments, should not be used, as grease or oil tends to dissolve and spread the poison. In the later stage, after the toxic material has exhausted itself, zinc-oxid ointment and similar mild antiseptic and astringent applications hasten healing.

A simple formula[10] useful both at this and the early stages is the following, which may be dabbed on the poisoned parts after thorough cleansing or applied by saturating one or two thicknesses of a light bandage:

Zinc oxid	15 grams.
Phenol	2 grams.

Lime water to make 250 cubic centimeters.

ERADICATION OF POISON IVY AND POISON SUMAC.

It is usually possible to find persons who do not easily take ivy or sumac poison who can be employed to remove the plants, but with the exercise of proper care almost anyone may undertake the work without incurring injury. Those who are sensitive to the poison and thus have special reason to fear the plants may undertake the work of eradication late in the fall or during the early spring, when the danger of injury is least.

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[10] White, James C. Dermatitis venenata. Boston, 1887.

Overalls and heavy gauntleted gloves should be worn for protection while engaged in the work. These, with shoes and all articles of clothing which have come in contact with the plants, should afterwards be changed, taking care to avoid injury from the poison which adheres to them and which may make them a possible source of harm for an indefinite period. Thorough washing, in the manner previously recommended, should invariably be practiced after exposure to the plants, and in the washing of clothing or articles contaminated with ivy poison similar precautions should be adopted.

DESTRUCTION OF POISON IVY.

In undertaking to destroy poison ivy, the feature to be borne in mind is that the plant arises from creeping underground stems which spread in all directions a few inches below the soil surface and from which new branches or shoots arise at frequent intervals. The various methods of eradication and control follow:

Chemical methods.—The parts of the plants above ground are readily killed by spraying with strong brine (3 pounds of salt to a gallon of water), but additional sprayings are necessary to kill the new shoots which soon arise from the rootstocks.

A better method, especially for killing vines on fence posts and on trees, is to cut the poison ivy below the ground and then saturate the soil around the cut bases of the plants with salt brine. A second dose of brine should be applied about two weeks later if the roots show signs of putting forth new growth.

Thorough wetting with kerosene oil, applied with a spraying pump or sprinkler, will kill the plants after one or two applications. The effectiveness of the treatment will be increased if the soil is disked or cut up slightly, so as to expose the roots to the action of the kerosene. As kerosene will injure or destroy all vegetation it is not safe for use around valuable trees and shrubs.

The plants may be killed by spraying them with a solution of sodium arsenite of a strength of 1 pound to 5 gallons of water. This chemical is extremely poisonous, and when it is used caution should be exercised both to prevent injury to the person applying it and to keep horses or other stock from eating the poisoned plants.

Crude sulphuric acid may be used, applying a few drops of the chemical to the bases of the plants at intervals of a week until they die. This may be done conveniently by means of a copper spring-bottom oil can, such as machinists use. Care must be taken to avoid spilling the chemical on the hands or clothing, as it is a dangerous caustic.

Hand methods.—The most rapid and effective way to deal with small isolated clumps of poison ivy is simply to pull or grub them out, taking care to remove thoroughly the running underground parts, since pieces of these left in the ground will soon produce another crop of plants.

The plants are killed by frequent mowing, carried out persistently so as to prevent the roots from developing green growth above ground.

Plowing and cultivation.—When poison ivy infests grasslands or other situations where plowing is practicable, the best method of eradication is to plow the soil and plant corn or other hoed crops. The frequent cultivation given to such crops will starve the underground parts of poison ivy remaining in the soil.

Smothering.—Small patches of poison ivy may be killed by covering them with tarred or other heavy paper, to the complete exclusion of light. The edges of the paper should be either pegged or well weighted down.

Pasturing.—Sheep and stock browse on poison ivy without apparent harm to the animals. They may thus be used to hold poison-ivy growth in check, but under ordinary conditions the use of other methods will be necessary to secure complete eradication of the plant.

DESTRUCTION OF POISON SUMAC.

Since poison sumac for the most part grows in swampy, inaccessible locations, the expense of eradication is usually not warranted. However, the plant is often found at the edges of paths or roadways bordering upon moist land or on the banks of streams in frequented places, where its presence is the cause of much injury. In situations of this kind it should be completely eradicated. A feature of the plant which adds to the danger is its attractive autumn foliage. Branches are frequently gathered by persons who are not acquainted with the harmful properties of the plant and are painfully poisoned.

In undertaking the work of eradication, the wearing of overalls and heavy gauntleted gloves as well as taking the other protective measures already recommended are of even greater importance than in the case of poison ivy, since the sumac plant contains the poisonous principle in greater abundance and is in consequence more dangerous.

METHODS OF ERADICATION.

The available methods of eradication are the following:

Grubbing.—Where poison sumac produces a bushy growth, the most practical method of eradication is simply to grub the plants out completely with a mattock, grubbing hoe, or other suitable implement. It is important to remove the roots as completely as practicable, since parts of the root system left in the ground are capable of producing new shoots.

Cutting and treating with chemicals.—When it is desired to destroy poison sumac by means of chemicals, and this is the most practical procedure where it grows as a small tree, the plants should first be cut off close to the ground. The newly cut surfaces and the ground surrounding should then be covered with a thin layer of salt, which will tend to prevent sprouting. Kerosene, crude oil, sulphuric acid, or a solution of sodium arsenite, already described in connection with the eradication of poison ivy, may be used, but the cheapest grade of crude salt will be found equally as effective and is the most economical.

THE BEST TIME TO ERADICATE POISON SUMAC.

Where, as frequently happens, the poison sumac grows in land that becomes dry during part of the year, the dry season is especially favorable for destroying the plants by cutting, since during this period the roots are least likely to sprout and therefore are more readily killed. To avoid the greater risk of injury incurred in handling the plants while the sap is abundant, and especially during the season when the foliage is dense, making avoidance of contact very difficult, it may be preferable simply to mark the plants, so they can be readily identified after the leaves have fallen. The work of eradication may then be undertaken during the fall or winter, when it is possible to handle poison sumac with less risk, but it should be remembered that severe poisoning may be caused both by the plants and roots at all stages if handled without the protection of gloves and without taking other precautions to prevent the poisonous material from being deposited on the skin. Winter cutting is not as effective as summer cutting, because during the winter most of the food material of the plants is stored in the roots and consequently they tend to sprout profusely the following spring. It is necessary, therefore, to kill the sprouts in the spring by a liberal application of crude salt, crude oil, or other chemicals, in the manner already described. Simply cutting the sprouts is ineffective unless repeated frequently throughout the growing season.

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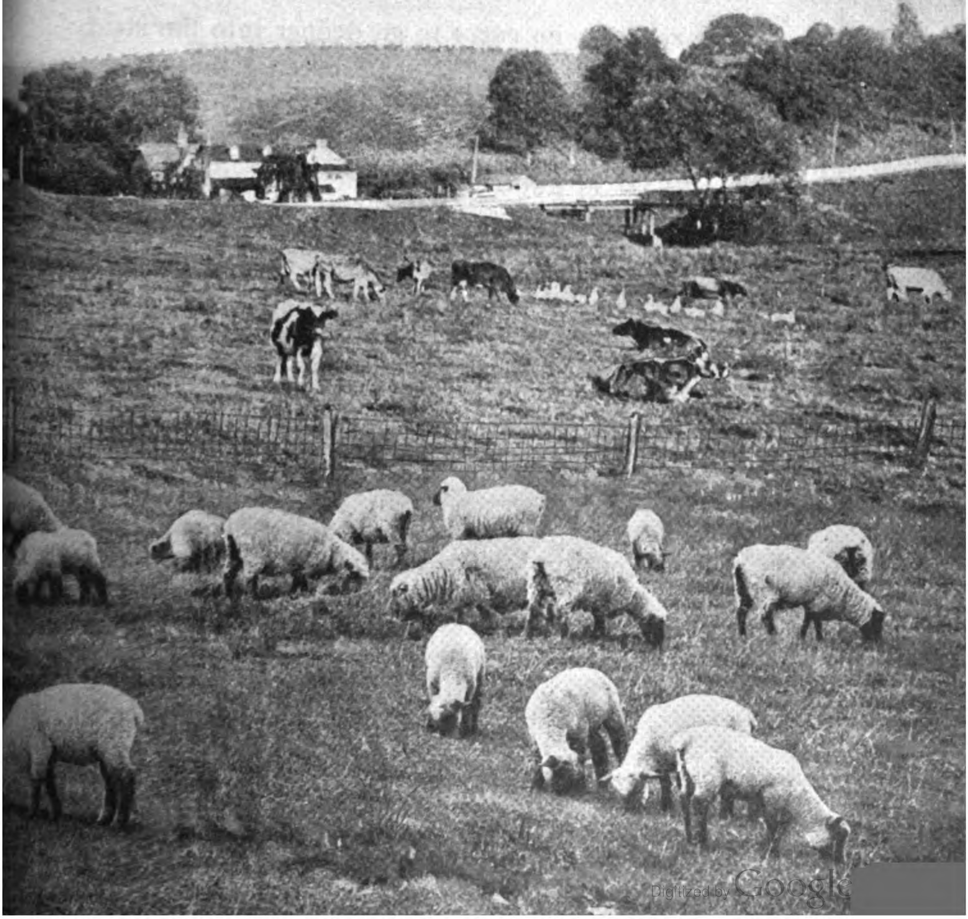
ESSENTIALS OF ANIMAL BREEDING



THIS BULLETIN is written in simple language for the man who breeds farm animals, who wants to learn the rudiments of the science of breeding, and how to apply them in practice. It sets forth some of the known facts regarding the operation of the forces of heredity. Controversial subjects are avoided so far as possible.

The reader who cares to go deeper into the study of genetics is referred to textbooks on the subject, and particularly to Department Bulletin No. 905, "Principles of Livestock Breeding," by Sewall Wright. It is published by the U. S. Department of Agriculture, and is obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents.

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief
Washington, D. C. November, 1920

ESSENTIALS OF ANIMAL BREEDING.

George M. Rommel,
Chief, Animal Husbandry Division.

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BASIC FACTS ABOUT HEREDITY.

IN DEALING with the subject of heredity we must recognize clearly the following facts: First, animal and plant forms, as a rule, have developed gradually and very slowly, by very small changes; in short, by the process known as evolution. Second, whatever an animal has, so far as its inheritance is concerned, it gets from its parents—they get theirs from their parents, and so on clear back to the beginning; nothing was imposed from the outside. For the present, accept this fact without question. We shall try to make it clear later. Third, a very clear distinction should be drawn between the effects of inheritance and the effects of food and environment.

Every one who is at all familiar with domestic animals knows what a wonderful effect the food an animal eats has on its development, especially when it is young. It is also known that the younger an animal is the more readily it is influenced by its food. Now, from the very first moment that a young animal begins to develop, from the very instant that growth begins with the fertilization of the egg cell, it receives food from some source or it dies. When it is only a single cell it is being fed. If a young animal after birth is

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NOTE.—In the preparation of this article, the writer received material assistance from officers of the Bureau of Animal Industry, especially Messrs. F. R. Marshall (now secretary of the National Wool Growers' Association), Sewall Wright, Dr. John R. Mohler, and Mr. D. S. Burch. He is also greatly indebted to Mr. Dewitt C. Wing, of Chicago, who made many helpful suggestions.

easily influenced by its food, how much more will the delicate little creature, known as the fetus or embryo, be influenced by the character of its food supply. A clear recognition of this fact will explain many occurrences which are often attributed to supernatural influences, and, at the same time, the breeder who recognizes this fact will not neglect proper attention to the nourishment and care of the pregnant mother as well as the nursing animal.

Accidents and disease also are important in their effects on the growing embryo. If an incubator is neglected on a cold night and the eggs become chilled, the hatch is seriously impaired and a large number of chicks are killed in the shell. If an in-foal mare is subjected to very heavy strains or forced to pull extremely heavy loads, the foal may be born too soon or even be killed in the womb. Contagious abortion may get into the herd without the owner's knowing it and cause the loss of a large proportion of calves. Heredity, however, has nothing whatever to do with any of these things.

THE SCIENCE OF BREEDING.

THE UNIT OF LIFE.

The smallest unit of life is the cell. A single cell is very small, usually of microscopic size. It is surrounded by a membrane, and each cell usually contains a nucleus—a sort of center of the things that go on in the cell. The animal body contains millions of cells, but those in which we are most interested at this moment are the cells from the union of which a new animal life begins. They are the germ cells. They contain the hereditary material which determines the identity of each individual and which is known as the germ plasm. This is the bit of life which passes down the line of descent with each succeeding generation. It appears in the mother in the egg cell, and in the father in the sperm cells. This material is composed of elements which seem to be handed on unchanged from generation to generation. Only a portion of the elements in the germ plasm of the parent goes into each egg or sperm, however, as is explained in more detail later. The element of chance enters to such an extent in determining which elements shall go into a particular germ cell that there may be a marked dissimilarity among individuals which are members of the same family. Even more important than the influence of food on the developing embryo and the young, growing animal is the operation of chance in determining the identity of the new life.

The cells from which all life starts are developed in the generative organs. The egg (the female cell) is developed in the ovary of the female; the sperm (the male cell) is developed in the testicle of the male. In mammals each female has two ovaries, one on each side, situated in the abdominal cavity. Connecting the ovaries with the uterus are the Fallopian tubes. The uterus is the womb, the chamber in which the young fetus develops until it is ready for birth. The uterus connects with the vagina, through which the sperm is introduced into the uterus and down which the young animal passes at birth. The genital organs and the urinary organs have the same outlets from the body.

When an egg matures in the ovary it passes down the Fallopian tubes into the uterus. If no sperm is introduced, the egg is thrown off infertile. In female animals an egg matures at fairly regular intervals, and this corresponds with some exactness to what is known as the period of heat or œstrum.

The period of heat varies considerably in different species and in different breeds and individuals of the same species. It usually occurs at intervals of about three weeks. In mares it appears on the ninth day after foaling, lasting two or three days. In cows it appears in from three to four weeks after calving when the cow is not suckling a calf, and in from six to eight weeks if she is. The heat period lasts only about one day in cows. Sows come in heat three days after farrowing, and not again until a week after the pigs are weaned. In sheep, except for a few breeds, such as the Dorset, ewes in North America ordinarily come in heat only in the fall for a number of periods of two or three days each at intervals of from two to three weeks.

Females usually accept service only during the period of heat. It seems to make little difference when service is made, whether early or late in heat. As a rule, not more than one service is necessary during one period of heat to insure conception. After conception takes place, the female does not generally come in heat again during pregnancy.

Male cells, or spermatozoa, are carried in the seminal fluid. There is only one egg, as a rule, except in such animals as hogs, rats, and others, which usually have several young at a birth. There are, however, millions of sperm cells, but only one of them is needed or used to fertilize one egg. Let us now proceed to a consideration of the first step in the formation of the new life.

THE BEGINNINGS OF LIFE.

The life which results when two animals are mated has its controlling elements in the nuclei of the germ cells. These nuclei contain a substance called chromatin, represented by very minute bodies called chromosomes. Chromatin and chromosomes are found in all cells all over the body, and the number of chromosomes in each cell is the same for each species of animal. Except for the accessory chromosome (which determines sex), they are always in pairs.[1] In many of the domestic animals and in man the number of chromosomes is between 40 and 48, depending on the species. Just why this number should be limited and invariable we do not know. It is no more remarkable, however, that each cell in the hog's body, for example, should have 40 chromosomes (which is the case) than that each normal hog should have four legs.

This is easily understood until we come to explain what happens when the egg cell is fertilized at conception. Obviously an egg with 40 chromosomes and a sperm cell with 40 chromosomes could not unite, because that would result in a cell with 80 chromosomes and only 40 is the rule. It just wouldn't work, any more than a pig with eight legs would work. Therefore, to prevent the doubling of the number of chromosomes at conception, nature puts the germ cells, both male and female, through a maturing process known as maturation, so that, just before the two unite, each has only half the normal number of chromosomes for the species, one from each of the pairs present before maturation.[2] When the two cells unite, therefore, the fertilized egg has the usual number of chromosomes carried by the cells of the species. *This process occurs only in the case of reproductive cells.*

When two animals are mated, what happens? The reproductive cells have gone through the maturing process and are now ready for union. The sperm cells are active and move around until they come into contact with the egg. Several may surround the egg, but only one unites with it. The membrane surrounding the egg cell is pierced by the head of a sperm cell. The two become one and the egg is now fertile. It needs only nourishment to become in time a full-fledged baby member of its race.

Food, of course, will have a profound influence on this little mite of life, but, so far as we know, the character of the resulting animal, its sex, its identity, and its individuality, whether it is to be white or black, long-haired or short-haired, ring-streaked or spotted, are now settled by the laws of life. This minute cell now carries in itself all the force of inheritance from all the ancestors behind it to the beginning of life on earth. Every champion you or I have known began his career in just this way. Many, many influences stepped in and had an effect on his subsequent development. Some of these are easy to determine, but others are so obscure that theories and fancies have grown up to explain them.

What value has this information for the practical breeder? Can he use it in making his methods more efficient? He can not use it directly, but indirectly it can be most valuable to him, because it explains many things that otherwise are difficult to understand.

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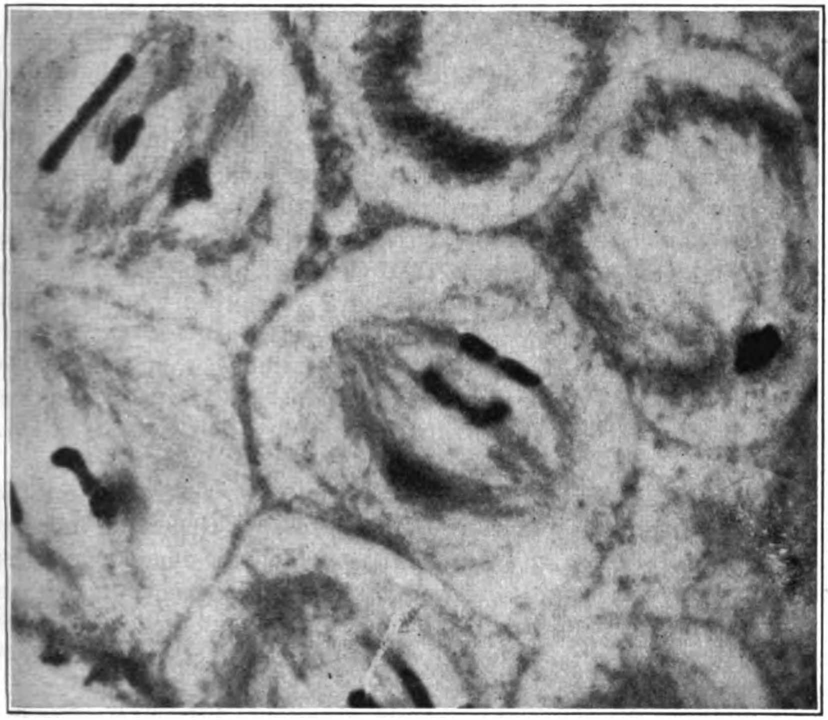
[1] For a discussion of the accessory or X-Chromosome, the reader is referred to textbooks.

[2] Biologists call this process *spermatogenesis* in the case of the male germ cells and *oögenesis* in the case of the female germ cells.

Suppose we are breeding animals in which the number of chromosomes is only four (two pairs). By the time both egg and sperm cells had gone through the maturing process, and the egg had been fertilized, 16 different combinations would be possible, some of them no doubt differing very little from each other, but others having little mutual resemblance. In animals such as hogs, however, with 20 pairs of chromosomes in each cell, the possible combinations are almost infinite in number.[3]



What Chromosomes Look Like.
(Courtesy of Dr. E. E. Carothers.)

FIG. 1.—A remarkable photograph of a group of maturing male germ cells taken through a high-power microscope. The pairs of darkly stained chromosomes may easily be seen in two of the cells in the act of separating to form the nuclei of two new cells. Each of these resulting cells will have only half the original number of chromosomes and will thus be ready for union with a similarly reduced egg cell. Hereditary characteristics are transmitted in the chromosomes.

The factors which make up the identity of the chromosomes bear very much the same relation to heredity that atoms bear to chemistry.

These combinations are the results of chance. Here we have an egg with 20 pairs of chromosomes, about to mature. Twenty of these chromosomes only will be left when the egg is ready to unite with the sperm cell. What 20 will it be? Chance alone can tell, except that there will be one from each pair. Here comes the sperm cell, to mature which a similar process was gone through. Chance again determined that 20 out of the original 40 chromosomes should disappear and no determination can be made to show which 20 would prevail. But this is not all. The sperm cell does not come alone. It comes in swarms, but only one sperm cell penetrates the cell membrane and fertilizes the egg. What determines which of the thousands of sperm cells will be the one? Chance again.

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[3] **The number of possible combinations in this particular case is 1,099,511,627,776.**

The chromatin is the chief, if not the sole, determining factor in the development of the identity of the new individual, and the chromosomes are the agents by which this identifying process is carried out. When we think of the great number of combinations of chromosomes possible before fertilization is actually effected, we begin to understand why it is that members of the same family often do not look alike and why we have so many disappointments in breeding animals.

If chance is the sole factor in determining what chromosomes shall persist, where does intelligent breeding come in? Of what advantage is it to exercise care in matings? Why not leave it all to chance?

The simple answer to these questions is that we can lessen the probability of undesirable working of the laws of chance by increasing the uniformity of the chromosomes. That is done by careful selection to a certain type and by working with a group of animals whose ancestry is known. The highest examples of such methods are found in the work of breeders of purebred livestock where unbroken and known lines of descent run back for a great many generations, sometimes for 50 years or more on a single farm under the ownership of a single human family. The discussion of the subject of selection will be found under that heading later.

THE GESTATION PERIOD.

From the time the egg is fertilized, developments are rapid. The fertilized egg divides and subdivides with multitudes of subdivisions, until in time the embryo "begins to look like something," and we can make out the form of the animal and its parts. The time between the fertilization of the egg and the birth of the young animal is known as the period of gestation. This period varies with the kind of animal. The period for the common domestic animals is shown below, followed by a table to determine how long a time may be expected to elapse between service and birth. To make a practical application of the table count forward the correct number of days from the date of service.

Gestation period of various animals.

Mare	11 months (340 days).
Jennet	12 months (365 days).
Cow	9½ months (280 days).
Ewe	5 months (150 days).
Goat	5 months (150 days).
Sow	4 months (114 days).

Probable date of birth of young, female bred on first day of the month (Sewall Wright).

Date of service.	Probable date of birth.			
	Sow.	Ewe.	Cow.	Mare.
Jan. 1	Apr. 25	May 31	Oct. 7	Dec. 7
Feb. 1	May 26	July 1	Nov. 8	Jan. 7
Mar. 1	June 23	July 29	Dec. 6	Feb. 4
Apr. 1	July 24	Aug. 29	Jan. 6	Mar. 7
May 1	Aug. 23	Sept. 28	Feb. 5	Apr. 6
June 1	Sept. 23	Oct. 29	Mar. 8	May 7
July 1	Oct. 23	Nov. 28	Apr. 7	June 6
Aug. 1	Nov. 23	Dec. 29	May 8	July 7
Sept. 1	Dec. 24	Jan. 29	June 8	Aug. 7
Oct. 1	Jan. 23	Feb. 28	July 8	Sept. 6
Nov. 1	Feb. 23	Mar. 31	Aug. 8	Oct. 7
Dec. 1	Mar. 25	Apr. 30	Sept. 7	Nov. 6

Variations in the period of gestation for animals of the same kind are not readily explained. Some animals, such as sows, are quite uniform in the length of the gestation period. In mares there is a considerable variation. It has been suggested that in mares some time may elapse between the moment of service and the actual fertilization of the egg by the sperm cell. In guinea pigs the size of the litter affects the period of gestation, the period being shorter for a large litter than for a small one. The health of the mother during pregnancy also has an effect.

During the gestation period the young animal is carried in the mother's womb and is not connected directly with her body. The blood vessels and nerves of the mother do not connect with those of the growing embryo, but from the start the little one has its own little system of circulation and its own nervous system. It is carried in an enveloping sac which is attached to the wall of the mother's womb by buttons (cotyledons) which become detached when the time comes. The young are nourished by blood passing from the mother's body through the walls of the uterus into the sac in which the fetus is carried, and thence into the body of the young animal by transfusion, much as water would pass into a paper sack if you should lower it into a bucket of water.

INCUBATION PERIOD IN BIRDS.

In birds the incubation period corresponds to the gestation period in mammals. The period which elapses from the time eggs are put on to hatch until the chicks emerge is shown below. Young birds are nourished in the embryonic stages of their development by absorbing from the yolk the nutriment needed.

Incubation period of various birds.

	Days.
Goose	30
Duck	28
Turkey	28
Guinea fowl	25
Chicken	21
Pigeon	17

Much may be learned by any one of a studious nature by careful observations of the development of the embryo of chickens. The germinal disk may be plainly seen even in a fresh-laid egg, which, whether fertile or not, looks the same to the naked eye. When put into an incubator, however, the fertile egg begins to develop rapidly, and the transformation in the brief period of three weeks is wonderful. The course of this development in fertile eggs can be distinguished easily from day to day by the familiar process of candling eggs, or it can be studied in detail by carefully breaking the eggs into a saucer.

DETERMINATION OF SEX.

As the growth of the embryo progresses, sex becomes apparent. Sex seems to be determined by one of the chromosomes, and is probably settled at the time of conception.[4] The determination of sex is therefore a matter of chance over which the breeder probably has no control. For practical purposes, the breeder will find that, over a period of years, he gets nearly equal numbers of both sexes.

FECUNDITY.

The subject of fecundity is of great practical importance to breeders of animals. Fecundity depends very largely on the number of eggs which are matured at a given time by the female. Animals in which multiple births are the rule (of which sows are a common example) not only mature a considerable number of egg cells at one period of heat, but each one is fertilized by a separate sperm cell. In some cases, however, the fertilized egg may divide and twins or a larger number of young result. Such twins are known as identical twins, and are usually of the same sex, with very strong points of similarity. Young from multiple births, resulting from the fertilization of different egg cells, show as wide a difference in individual characteristics as young resulting from separate births. The most prolific of the common domestic animals are the birds. The domestic hen may lay more than 200 eggs in a single year.

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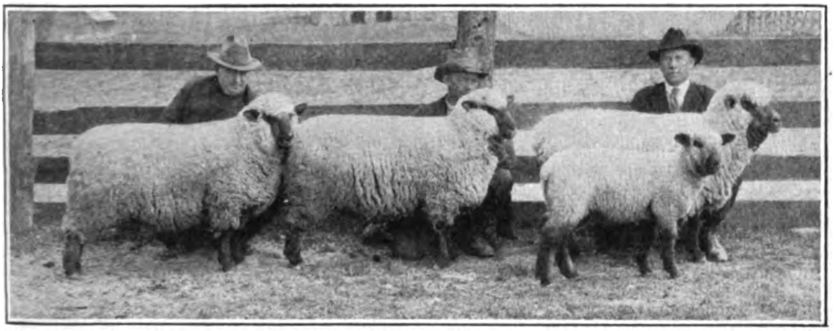
[4] See note (2) page 6.

The common practice of British shepherds, known as "flushing" ewes, has been claimed to increase the proportion of lambs in the flock. This practice consists in giving the ewes an increase in their feed, both grain and succulent pasture, so that they are gaining in weight and condition at breeding time. No exact scientific data have been available until recently, when Marshall and Potts, of the Bureau of Animal Industry, conducted experiments which confirmed the correctness of the British practice. They also have evidence which indicates that the success of the practice depends on cutting off the grain ration and putting the ewes on short pasture as soon as they are bred.



What a Good Mother Can Do.

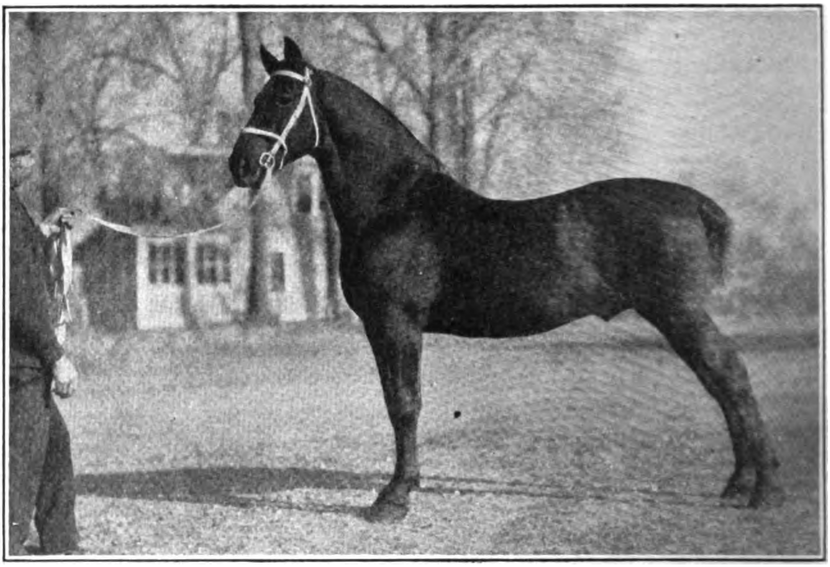
Fig. 2.—The ewe at the right was lambed in March, 1914. She was a prize winner as a yearling and as a two-year-old. Her first lamb was a ram dropped in 1916. Since then she has had seven lambs. The other two ewes are her twins of 1919 and were shown in the trio for Hampshire ewe lambs, winning first prize at the 1919 International Live Stock Exposition. The lamb at her side is her 1920 contribution to the wealth of America's purebred livestock industry.

The rules or laws of the inheritance of fecundity are not all known, but to some extent it is dependent on inheritance from the mother; therefore, the selection of females which have a tendency to produce a large number of young at a birth will tend to increase the returns from the flock or herd. This is of practical importance in the case of hogs, sheep, goats, and poultry. Twins in cattle are objectionable unless of the same sex. When a heifer is a twin with a bull calf, the heifer is known as a "freemartin" and in the majority of instances is sterile.

PREPOTENCY—MENDEL'S LAW.

Prepotency is the power of an animal, male or female, to stamp its characteristics on its offspring. If this ability is handed on to sons and daughters, we say that the stock "breeds on." In rare instances an animal, usually a male, is found, which has such power as a breeder that it leaves an indelible impress, even to the extent of becoming the fountain head of a new breed, such as the stallions Justin Morgan, Hambletonian 10, and Denmark.

Most of the cases of prepotency which the breeder usually meets with are probably instances of the operation of what is called Mendel's law. A clear explanation of this great law of heredity can not be made within the scope of this short article, and the interested reader, if he cares to go into the subject in detail, is referred to Dr. Wright's bulletin.[5]



How Good Blood "Breeds on."

FIG. 8.—Carmon, Standardbred stallion at head of United States Government stud, Buffalo, Wyo., a horse which has been remarkably successful in stamping his characteristics on his offspring. Photograph taken when Carmon was 20 years old.

It must be pointed out, however, that most operations of heredity are not simple; on the contrary, they are highly complex and often extremely difficult to understand. The chief use which the practical breeder of domestic animals can make of Mendel's law at this time is to find in it an explanation of occurrences that otherwise have no rational explanation.

One of the most interesting applications of Mendel's law in cattle breeding is the inheritance of the polled characteristic. If we breed a horned cow to a Red Polled, Galloway, Angus, or other true polled bull, the chances are 9 to 1 or better that we shall get a polled calf. The white face of the Hereford appears to be a similar instance.

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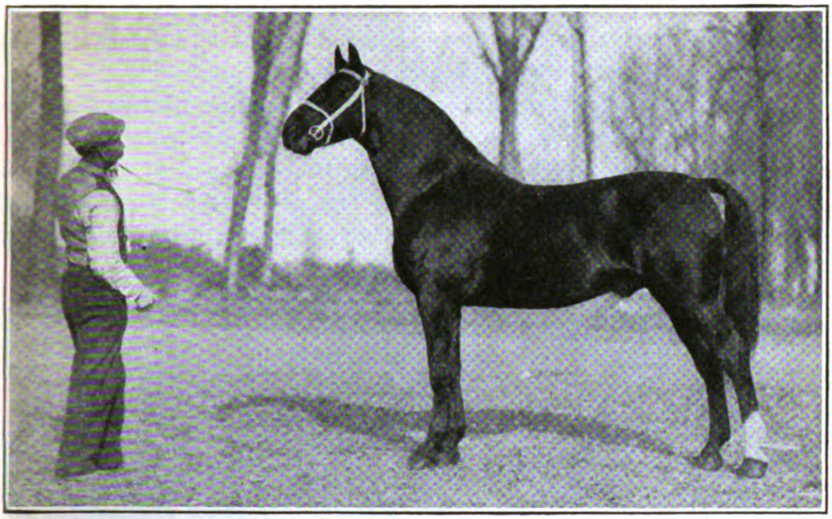
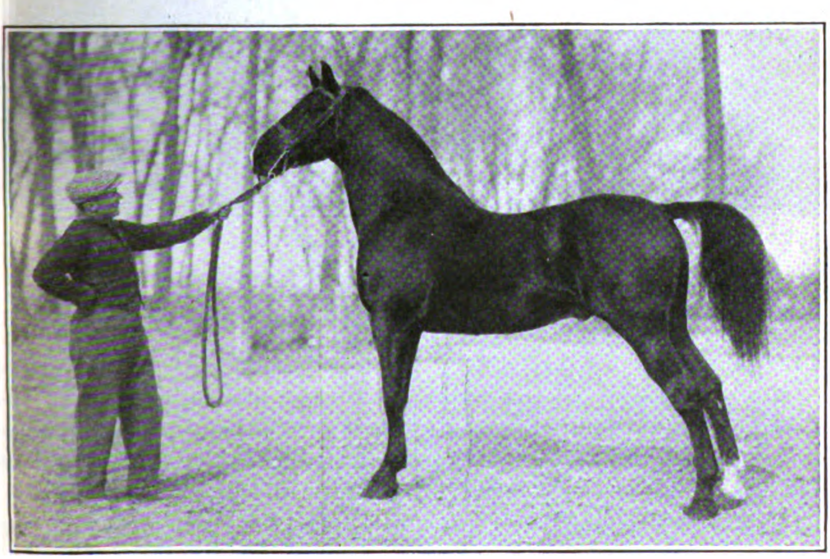
[5] U. S. Department of Agriculture Bulletin 905, "Principles of Livestock Breeding."



How Good Blood "Breeds on."

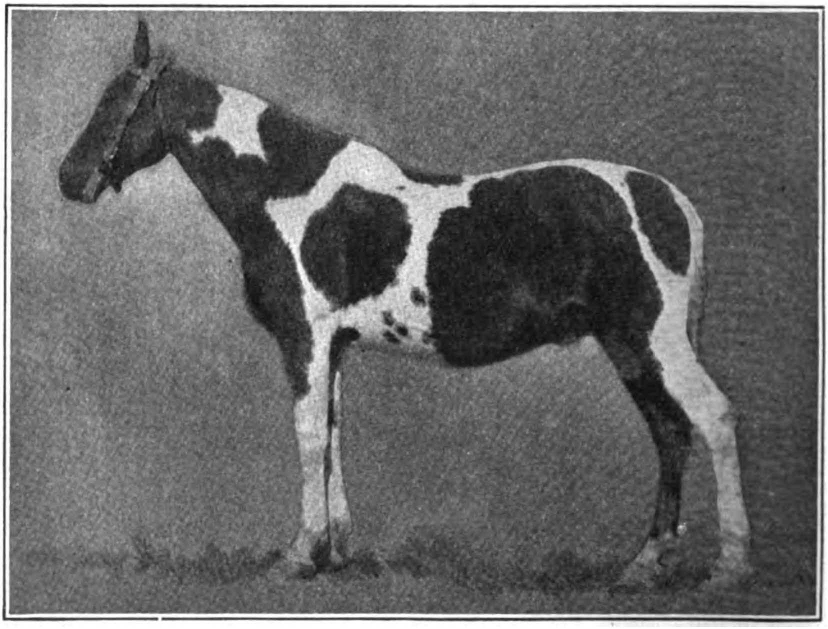
FIG. 4.—Albion, one of Carmon's first sons used in the Government stud as a sire. Note the remarkable resemblance between this horse and Carmon. Photograph was taken when Albion was nine years old.



How Good Blood "Breeds on."

FIG 5.—Defender, son of Albion. Photograph taken when Defender was six years old. Note that the type has been handed down from grandfather to grandson.

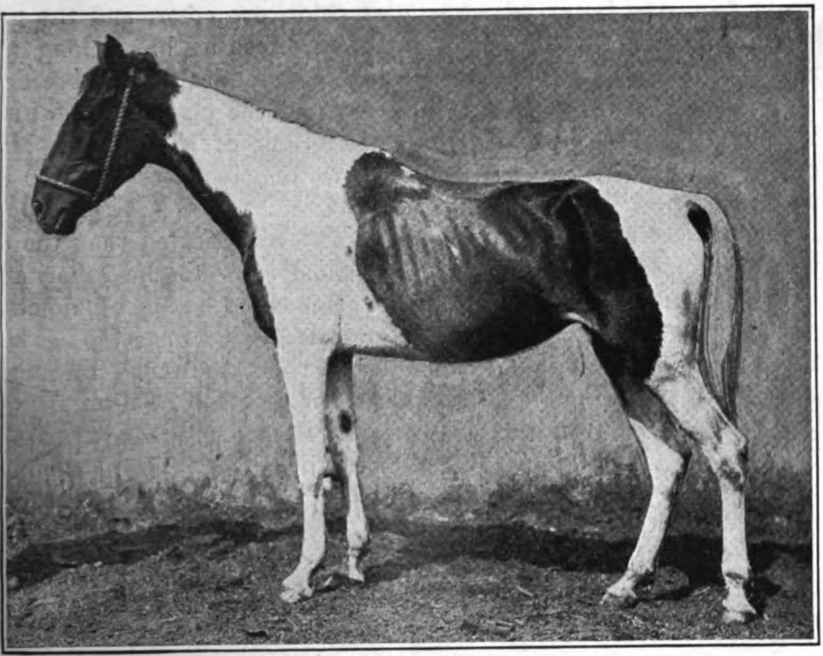
If we breed a common cow to a Hereford bull, we get a calf with a white face. We say, therefore, that polled breeds are very prepotent so far as "taking the horns off" is concerned, and that the Hereford is prepotent in putting a white face on his calves. This may happen either way; that is, polled bull and horned cow, or horned bull and polled cow, Hereford bull and plain-faced cow, or plain-faced bull and Hereford cow. The temptation is to make great claims for the prepotency of the breed as a whole on the evidence of one or two points only. For see what happens when we mate a Hereford with one of the polled breeds. Then we get a polled, white-faced calf. These points are not prepotency at all, but manifestations of Mendelian "dominance." The polled character is dominant over the recessive horned character, and the white face over the recessive plain face; but these cases do not necessarily indicate that the animal is particularly prepotent in other characters of much more practical importance. The same rule seems to apply in the inheritance of the black color in sheep, black acting apparently as a recessive to the usual white color. It can readily be eliminated by culling out the black lambs.



How Bad Blood " Breeds on."

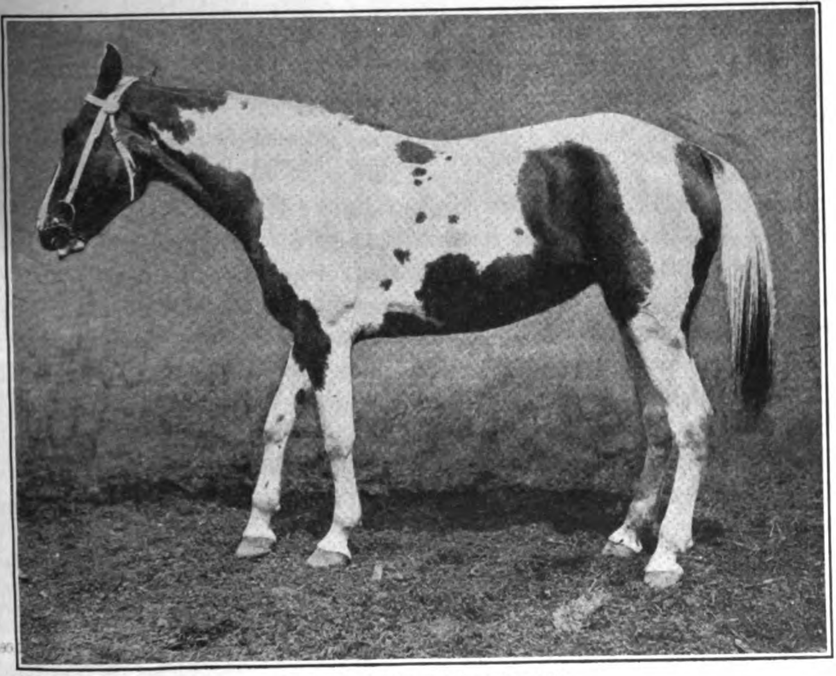
FIG. 6.—A spotted stallion of nondescript breeding used extensively as a sire in the community where he was owned. Note not only the bad color, which is almost unmarketable, but also the curby hocks and generally mean appearance.

A great many data have been accumulated as to the characters in animals which illustrate the operation of Mendel's law, but



How Bad Blood "Breeds on."

FIG. 7.—A daughter of the spotted stallion. Observe crooked hind legs, as well as bad color.



How Bad Blood "Breeds on."

FIG 8.—Another daughter of the same stallion. Note how the curby hocks have been transmitted and how there is also a striking tendency for the spotted color to prevail. Some of the stallion's bad qualities appear in the forelegs on this individual.

apart from the horns of cattle, coat color, eye color, and the like, the application of this law to livestock breeding has a long way to go before its principles are adaptable to practical use by breeders. It is fairly certain, however, that many of the obscure happenings in animal breeding are really manifestations of Mendelism. Most cases of atavism ("throw backs" to a remote ancestor), for example, are probably Mendelism in practice.

The animal structure is so diverse and complicated that the determination of the application of Mendel's law to the inheritance of the characters which affect the commercial value of domestic animals is a task of tremendous magnitude. Great progress has been made in laying the foundations for the scientific study of animal breeding by working out the principles of this law, and we may expect still greater progress in the future. Biologists who are studying heredity have their faces set in the right direction. The accomplishments of the last twenty years in the study of heredity have taken this subject out of the field of guesswork, and for this service all animal breeders are under obligations to Mendel and his disciples.[6] If, by skillful selection and intelligent breeding methods we can get results of permanent value; if, with the present knowledge, we can make real progress in animal breeding, we can afford to wait for the more definite working out of Mendel's law, with the assurance that this law controls the mechanics of heredity in domestic animals and that any practical application of it to animal breeding will add to our store of useful knowledge and to the efficiency of our breeding methods.

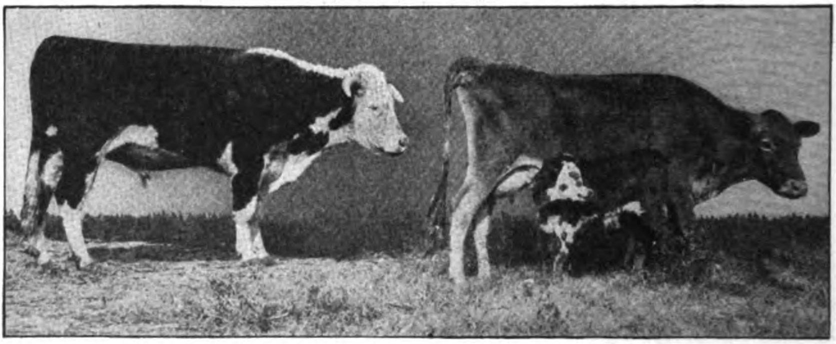


FIG. 9.—Purebred Hereford sire, scrub dam, and offspring. Note how the characteristic markings of the Hereford sire, especially the white face, are transmitted.

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[6] The discovery of this law by the Austrian monk, Gregor Mendel, in 1865, its virtual disappearance for 35 years and its rediscovery simultaneously by several investigators working independently, form one of the romances of science. Mendel's papers attracted very little attention when published, owing, no doubt, to the intense interest of the world in the researches of Darwin. Mendel died in 1884 without realizing the importance, to humanity, of the work which he had done.

THE ART OF BREEDING.

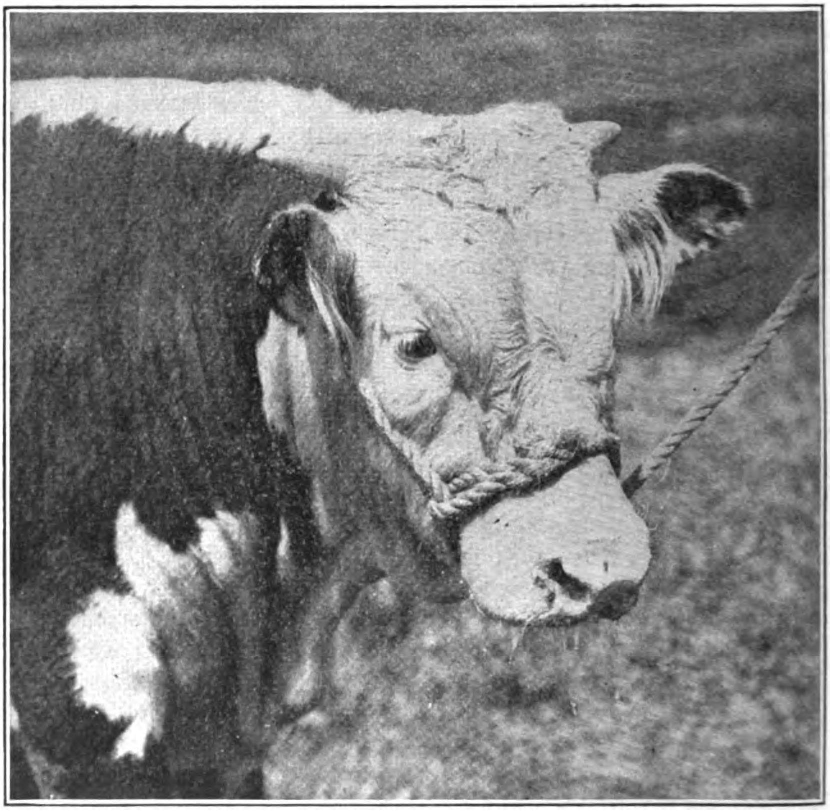
SELECTION.

Keeping in mind the principles laid down in the foregoing pages, it is clear to every one that in order to make the best out of the hereditary material represented in one's herd, and to use the laws of nature to the best advantage, one must have clearly in mind a standard which he sets for himself as the ideal toward which he must work. This standard must be definite and should be as practical and simple as possible. The exercise of selection, wisely and judiciously pursued, offers the breeder one of the two most effective means of bending to his own purposes the operations of chance, which otherwise nature will use to his confusion and undoing.

We have made the statement already that the hereditary material is passed down from generation to generation without change except so far as the operation of the laws of chance may have affected the process, beginning with the maturation of the germ cells. It is plain, however, that constant selection of a good type will increasingly intensify the properties of a given set of characteristics (in other words, of a definite type), but that this selection must be pursued constantly because the chromosomes which tend to produce the less desirable types continue to be present, although in decreasing numbers. If the force which has been selecting the desirable chromosomes is removed, then the undesirable ones may once more prevail. In other words, our modern breeds of farm animals are an improvement over the stock from which they sprang. There is, therefore, a constant pull backward and downward against which the breeder must work by wise selection and skillful matings. If this intelligent direction by human skill should be removed, our animal stock would rapidly degenerate to the level of the types of centuries ago.

Selection should be designed to correct faults in the parents, and, as a rule, the male is depended on to do it. A few concrete cases will illustrate. If the females have a tendency to be too leggy, select a male that is compact and close to the ground. If the backs are not ideal, select a male with an exceptionally strong back. If the sow's feet are not the best, get a boar that is unusually strong in his feet with strong, upright pasterns. We might multiply these illustrations indefinitely. Therefore, a sire should be a better individual than the females with which he is to be mated; otherwise the standard of the herd or flock may decline. To some extent a breeder may extend these principles to the grandparents, but for practical work on a farm that is producing market stock it is commonly unnecessary to go farther back than the sire to be selected. In other words, don't buy a poor male merely because some one tells you he has a good pedigree.

The breeding animals selected should look the part. Good bone; deep, broad chests; strong, broad backs; and fully developed bodies should be emphasized. Especial attention should be paid to the head, for that part of the body tells many a story which otherwise would be overlooked. Width between the eyes, full, prominent eyes of pleasing appearance, broad muzzles, and prominent nostrils indicate points of value both to the breeder and the feeder. In males, strong evidence of masculinity is important. The evidence of the masterful impressiveness of the masculine sex is often apparent in very young animals and may be taken to indicate a youngster that with proper feed and care will grow out into an impressive sire. In females we look for femininity, without indications, however, of weakness of constitution. Avoid cows, for example, with heads like those of steers. These points make up in total what breeders call "charac-



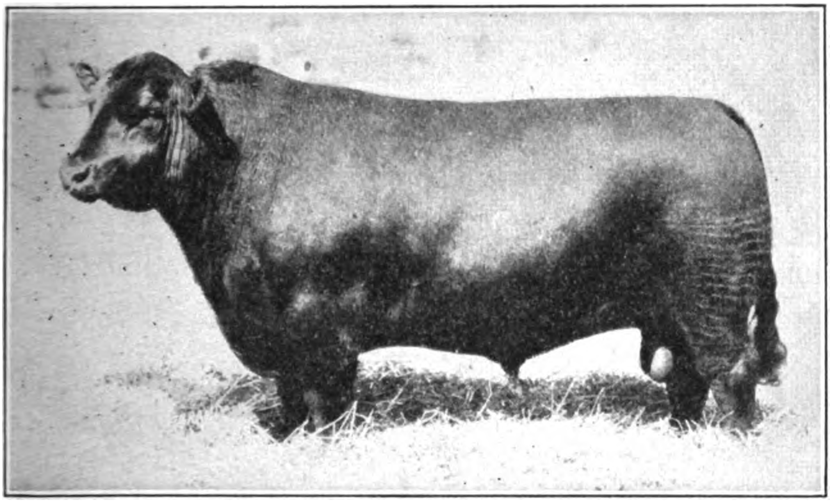
Hereford Calf Illustrating Character.

FIG. 10.—Compare this picture with those of other bulls shown. Each one shows strong masculinity. Each one has an individuality as marked and striking as the individuality shown in photographs of human beings.

ter" and are among the most important considerations which a breeder must bear in mind in building up his herd or flock.

Good feed, care, and attention are valuable adjuncts to selection. Unless feeding permits full development we can not select intelligently the animals which have received and can transmit the characters we desire to perpetuate. Starved animals which never have had an opportunity to demonstrate their capacity to produce meat, milk, wool, or other valuable commercial products, furnish poor material from which to select individuals capable of maximum and most economical production.

One must use these rules of selection with judgment and common sense. While faults undoubtedly can be corrected by the use of males of superior individuality, it may be unwise to use some females for breeding even market stock because they may be too inferior for even this purpose. To sell them and substitute better individuals, either high grades or purebreds, is often the more sensible course and the more profitable in the end.



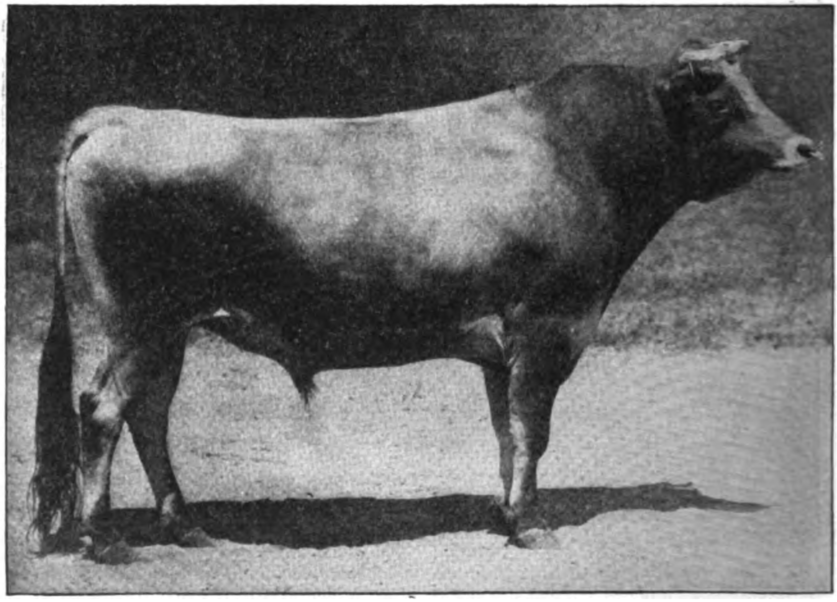
Idolmere.

Fig. 11.—Grand champion Aberdeen-Angus bull at the 1919 International Live Stock Exposition. One of the greatest bulls of the breed ever seen in an American show ring. An exceptional photograph of a great bull showing not only splendid beef conformation but outstanding breed character also. Note especially the strong character as shown in the head and neck, as well as the great length of the bull and his remarkable smoothness.

Selection alone, however, is not certain to result in steady progress. Different combinations of hereditary elements may result in apparently the same characteristic. In practicing selection a man may introduce at any time the blood of a line which merely looks like that of his own stock, but which breeds differently. The result is the undoing of past progress, the next generation showing the variability characteristic of the second generation of a cross. Only by breeding within relatively narrow limits can one be reasonably sure that he is mating animals which both look alike and have the same heredity.

INBREEDING.

Next in importance to selection as a means of improvement in breeding animals, the most effective process at the command of the breeder is the judicious mating of related animals. This process is known as inbreeding, and various terms, such as line breeding, close breeding, and incestuous breeding, have been used to define varying degrees of intensity of the process.

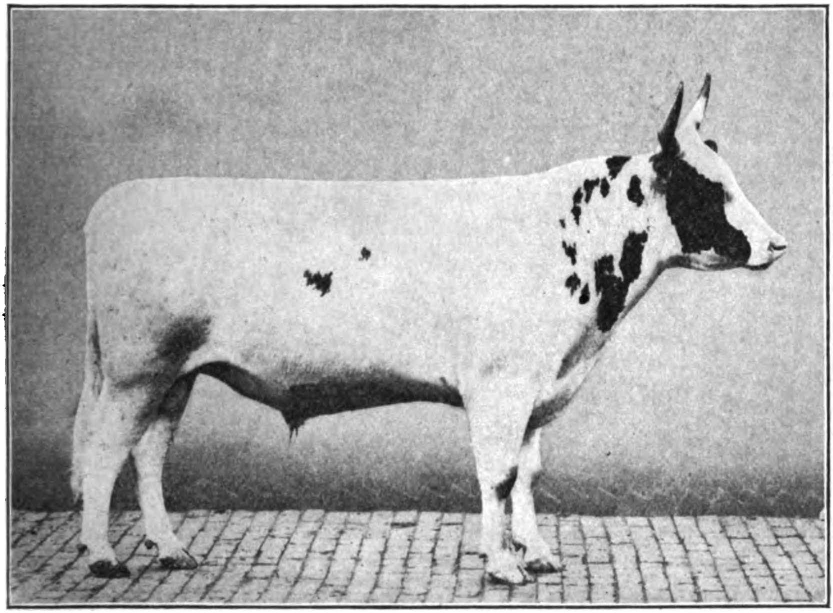


Jersey bull, Pogis 99th of Hood Farm No. 94502.

FIG. 12.—Animals such as this one show strong evidence of breed character, masculinity, and impressiveness.

Inbreeding is one of the most discussed subjects in the whole field of genetics. All sorts of bad results are attributed to it. Lack of vigor, nonresistance to disease, decline in size and fecundity, and even sterility are the fate of inbred animals, in the minds of many people. These ideas have a certain basis in fact, and often extend to farmers, who sometimes refuse to buy males which have inbred pedigrees. Breeds and families which have been intensely inbred for several generations develop manifestations of constitutional weakness which, it seems, can be explained only on the grounds of their close relationship. Scientific data of exact and elaborate scope, worked out under controlled conditions, are not abundant on this point.

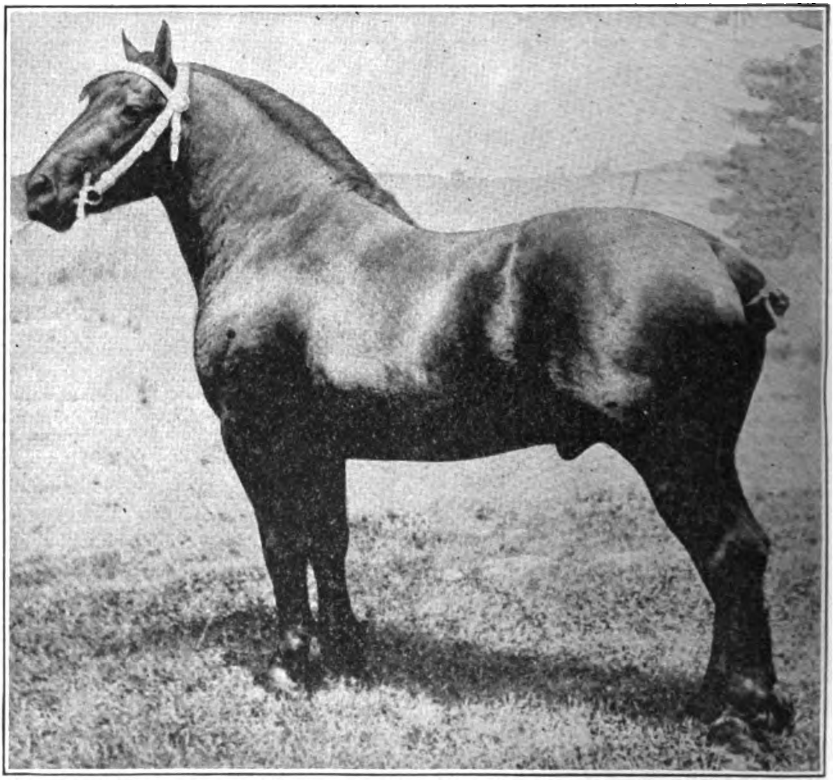
We have, on the other hand, the accepted fact that progress in animal breeding began only when breeders began to inbreed. The work of Bakewell, who experimented during the last half of the eighteenth century, which made the greatest impression was the methods he used, and the method that has been most far-reaching in its results was that he mated his animals with first regard to their individual suitability for the mating, and with secondary importance placed on their relationship. Since the time of Blakewell every breeder who has made an impress of permanent importance on his breed has used inbreeding as his most useful working tool.



Purebred Ayrshire Bull, Hobsland Perfect Piece 16933. (Senior Grand Champion Aryshire Bull. National Dairy Show, 1914.)

FIG. 13.—A good breeding animal impresses the observer in many ways. The pose of this bull, his lines, and the sweep from the head to the tip of the tail give an unmistakable impression of individuality, power, and merit.

When we mate related animals we are bringing together animals with a more nearly uniform character in their hereditary material than when we mate those that are not related. We are, therefore, increasing the probability that the offspring will be like the parents. But there may be hidden in the hereditary material the factors of an undesirable character. In other words, we may not know all that we should know about the ancestors. Back somewhere, perhaps, was a bad one whose traits are being bred out by selection in each successive generation. If we mate two related animals carrying this defect, we greatly increase the chance of perpetuating it. Instead of having an even chance or better of keeping the defect under subjection by not inbreeding, we double the chance of its appearing when we do inbreed. It seems possible to inbreed some animals much more intensely than others, and certain strains of breeds in the same species exhibit similar traits. To cite specific instances, cattle which have a special susceptibility to tuberculosis, horses with a tendency to certain unsoundness, such as roaring or spavin, should not be inbred. The safe rule, therefore, is not to mate closely related animals which have the same defects, either themselves or in their immediate ancestors.

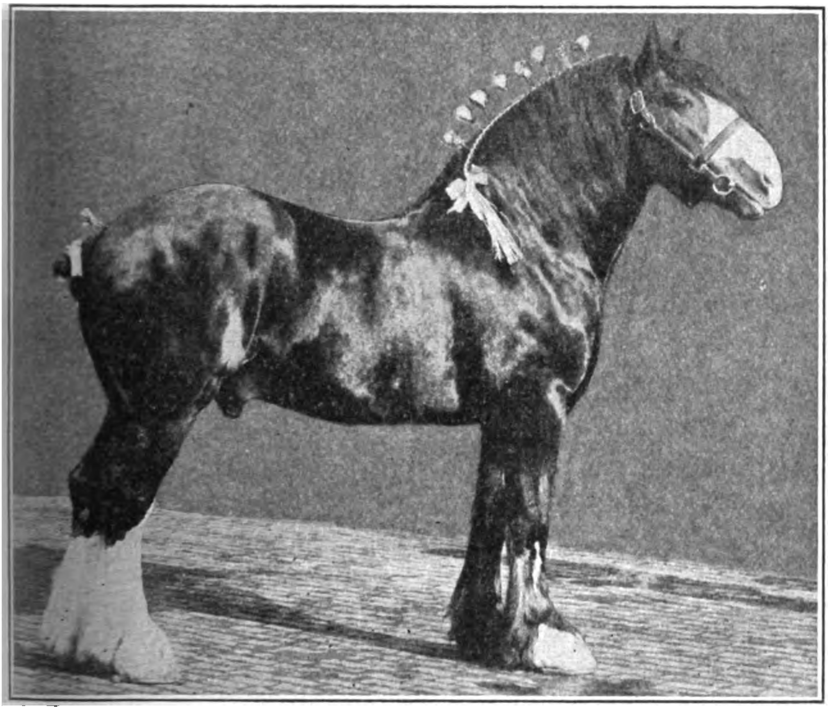


Percheron Stallion, Dragon.

FIG. 14.—Descendant of a long line of impressive ancestors and himself a sire of valuable draft horses.

Inbreeding should be practiced only by the most skillful breeders, and by them only when they have definite knowledge of the ancestry. Judiciously used, inbreeding results in a rapid fixing of type and enables the breeder to obtain results much more rapidly than without its use. It is like any other high-powered implement. Properly used, it is a wonderful adjunct to human efforts; in the hands of the ignorant and careless it is a source of danger.

The purchaser of inbred males, however, need have no fear of using them if they are creditable representatives of the breed. As a matter of fact, he should prefer inbred males to others, especially if they are not related to his females, because they are more nearly alike in their hereditary material, and for that reason more likely to reproduce themselves with uniformity. They are usually sold under a guaranty that they are breeders (or they should be so sold), and if they do not breed, any reputable breeder will replace them. It is a general rule that inbred animals, when mated to unrelated ones, even though the latter themselves are inbred, produce offspring larger and more vigorous than either parent. From every standpoint, therefore, an inbred sire should be desirable to use in a farmer's herd, provided the animal is a good individual. The farmer should make certain of this fact. Then he should ascertain that the strain itself is vigorous, and finally he should have a guaranty that the animal bought will prove to be a breeder. If these conditions are met, the farmer will find inbred males much more impressive and will have a much more rapid return in improving his stock than if he had used males which were not inbred.



Clydesdale Stallion, Fyvie Baron.

Fig. 15.—Note intelligent head and strong, crested neck, as well as evidence of vigorous constitution, indicated by depth of body.

Whether a breeder should or should not inbreed his stock is a matter which he must settle for himself. The successful use of inbreeding is one of the best tests of a breeder's skill, and no man should inbreed unless he is confident that he possesses the requisite skill to make such a step successful. Generally speaking, the inbreeding of market stock is unwise; but the use of inbred males on the females of such a stock may be of the highest value, provided the breeding establishment which produced the males has not been injured by inbreeding. Such a fact can be readily ascertained.

Inbreeding fixes characters which can be fixed, but one of its most valuable consequences is bringing clearly to light the relative merits of different strains in such characters as fecundity, resistance to disease, and the like, which are affected so much by factors other than heredity that they can not be fixed in individuals. In these cases progress is more likely to result from selection of strains than from the selection of individuals.

A real danger from inbreeding is not to be urged against the practice itself, but against the peculiar infatuation which breeders acquire for certain bloodlines. Once let a given line of breeding demonstrate its excellence for the production of a certain valuable type, and every progressive breeder strives to acquire some of this valuable blood. The strain soon becomes "fashionable." From this stage to breeding for the pedigree rather than for the animal is an easy step which is taken much too often. The corrective for such methods is the show ring, with competent and fearless judges in authority.

OUTCROSSING.

Quite the converse of inbreeding is the practice of outbreeding or outcrossing. Even in plants which are usually self-fertilized, nature has provided for an occasional outcross that materially increases the vigor, stamina, and general well-being of the stock. In animals which have been intensely inbred, outcrossing has interesting and important results. Mating to stock which has not been inbred results in increases in size and vigor. A similar result also follows the mating of two strains, both of which have been inbred, but which are not closely related to each other.

PURE BREEDING.

Step by step we climb the ladder of the art of breeding until we finally reach the top in the breeding of purebreds, the most fascinating, the most inspiring, and the most remunerative branch of animal breeding when successfully followed; the most difficult and the most disappointing when not successful. The successful breeder of this class of animal is far more than a business man or a farmer. He is an artist, and the artistic appeal is first in importance to him.

The basis of pure breeding in the United States, except in the case of poultry and pet stock, is pedigree registration. Animals must be not only purebred, but they must be registered in the book of record established for the breed.

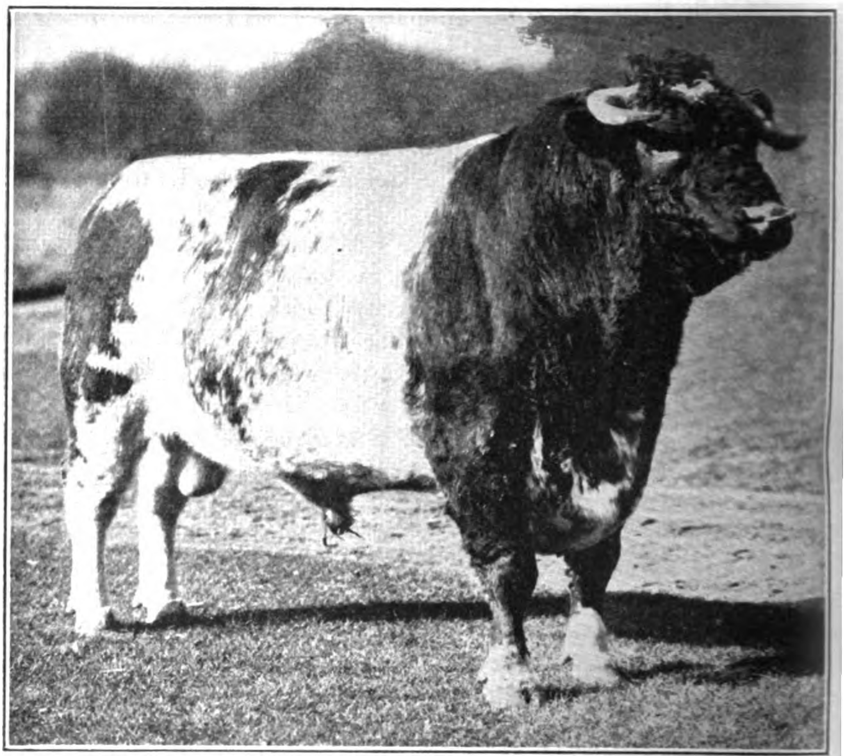
Standards in pure breeding are more exacting and more complicated than in breeding solely for the production of meat, wool, milk, or eggs, but they should be practical, because the proof of the practical value of a breeder's work is the demand which is sustained in the long run for his breeding animals. The surplus of the registered purebred establishments goes to improve the native and unregistered grade herds and into purebred herds of less merit. A high standard is therefore absolutely essential to maintain quality, average excellence, and the reputation of the herd. Practical ideals must have quite as much weight as purely commercial considerations in the determination of the standards.

A breeder's success depends to a very large extent on his ability as a qualified judge of animals, on his knowledge of the pedigrees of his animals, and on his acquaintance with the characteristics of the ancestors of those animals. The breeder's ability as a judge must be based on an instinctive gift to recognize animal types and carry them clearly in mind. This is of even more importance than a knowledge of pedigrees, because a knowledge of pedigrees is of practical value only as it gives its possessor an acquaintance with the individuality and type of the ancestors in the pedigrees, which he may use in making effective matings and thus perfecting the type of his animals. One of our most eminent breeders of hogs once made the statement, "I breed my hogs in the barnyard, with the animals before me, not in my parlor with their pedigrees before me." That homely statement carries a truth which every ambitious young breeder should follow. Before deciding to make a certain mating, the man who made this statement is said to spend hours studying his breeding animals, going over their characteristics, and especially recalling to mind the characteristics of their parents, grandparents, and more remote ancestors. If this review is satisfactory, the mating is made; if not, some other is tried.

To sum up, knowledge of a pedigree must not stop with the routine knowledge of the names of the animals which compose it. The breeder must know also the characteristics of these animals, as far back as possible, their weaknesses as well as their strong points. When he possesses this information the breeder can more intelligently mate individuals and blend bloodlines. He has then a practical working knowledge of pedigrees. The study of pedigrees, therefore, based on a knowledge of the characteristics of the animals composing them, is indispensable to the man who would excel as a constructive breeder.

THE VALUE OF A PEDIGREE.

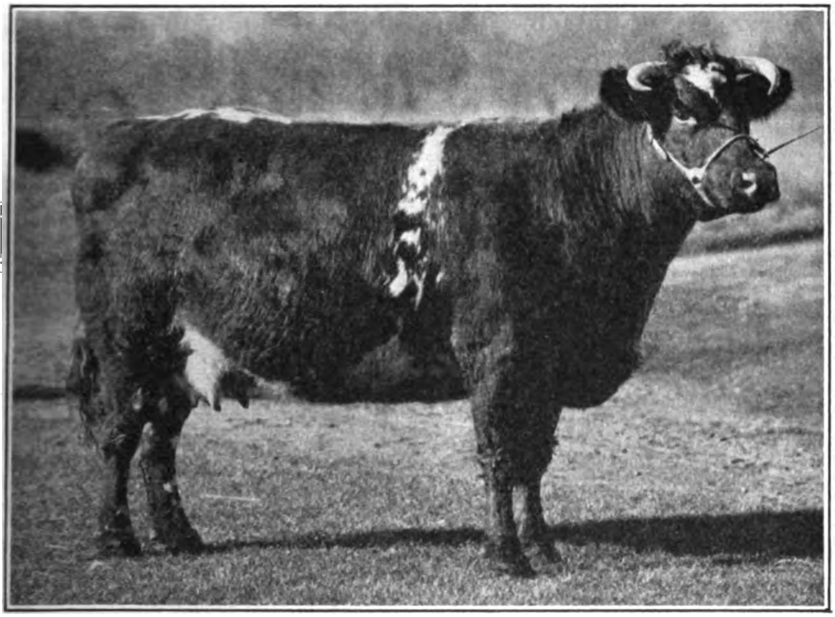
No one breeds animals without dealing with pedigrees. The common phrase "pedigree stock," as a synonym of "well-bred" or "purebred" in describing livestock, is a misnomer. All plants, all animals, all people have pedigrees, but all information about these pedigrees is not available. Pedigrees become known because of merit in some individual which stands out above his fellows. His progeny are watched, and if they have merit above the average they are "saved for breeding purposes," and by and by we have a line of known descent and ultimately perhaps a pedigree of distinction and formidable appearance. They are written into genealogies, herdbooks, flock books, and studbooks, and the inheritance of decades and even of centuries becomes in time a matter of written record.



The Sire of a Grand Champion.

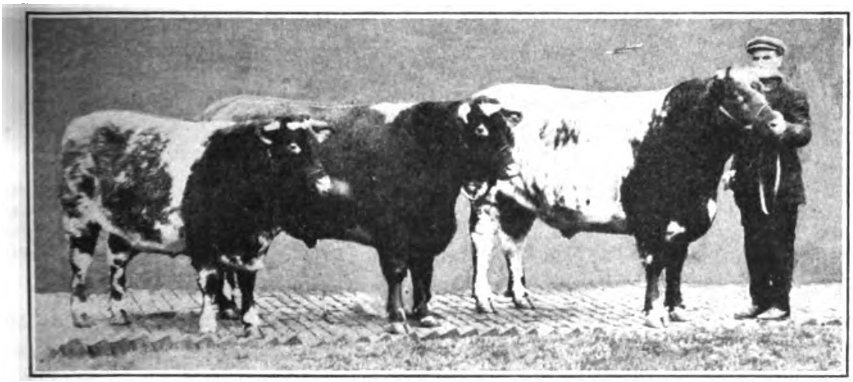
FIG. 16.—To achieve the highest results in livestock production pure blood is most likely to result satisfactorily. Illustration shows the Shorthorn bull, Lavender Sultan, sire of the three steers shown in figure 18. This bull is a remarkably impressive sire with wonderful thickness of flesh. Note how his thick flesh is transmitted to his sons. Compare this picture with figures 17 and 18.

The proof of the value of the pedigree itself is the worth of the animals it produces. The value of animals with certain pedigrees depends upon their ability to produce desirable types with greater excellence and uniformity than animals with other pedigrees or with no known pedigrees whatever. The power of the animal with a known pedigree to reproduce its type has been intensified by selection. Therefore, if the matings which have been made in constructing the



The Dam of a Grand Champion.

FIG. 17.—Merry Sempstress, dam of Merry Monarch, the grand champion steer at the International Live Stock Exposition in 1919. Note not only her beef conformation but her good feeding qualities, clearly indicated in a head which is almost an ideal feeder's type, as well as an ideal breed type. She shows excellent indications of real feminine character.

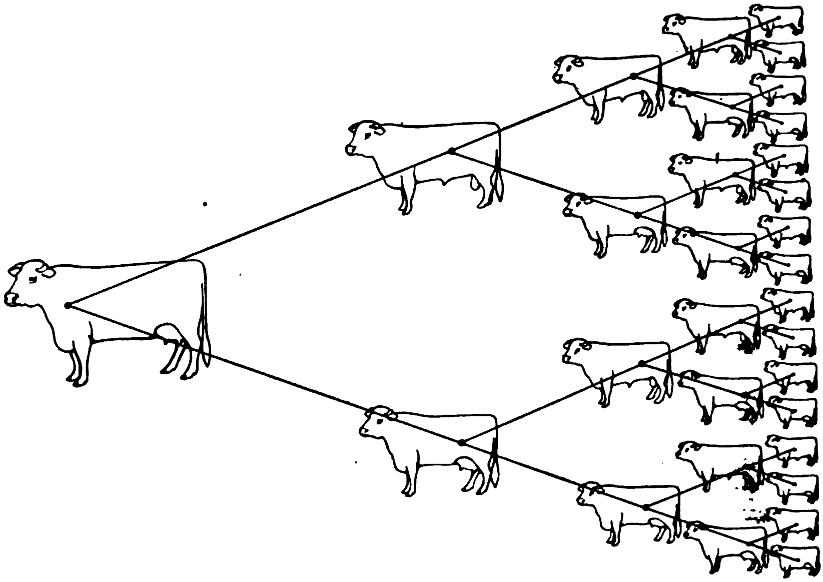


A Triumph of Breeding and Feeding.

FIG. 18.—Merry Monarch (right), grand champion steer at the 1918 International Live Stock Exposition, and two other prize-winning sons of Lavender Sultan. Compare with figures 16 and 17.

pedigree have not been directed by a high order of skillful selection, the animal may have intensified powers of producing an undesirable type, and may be what is commonly designated a "scrub purebred." The purchase of an animal or its use for breeding purposes solely on account of its pedigree is a dangerous matter and may result in much more harm than good.

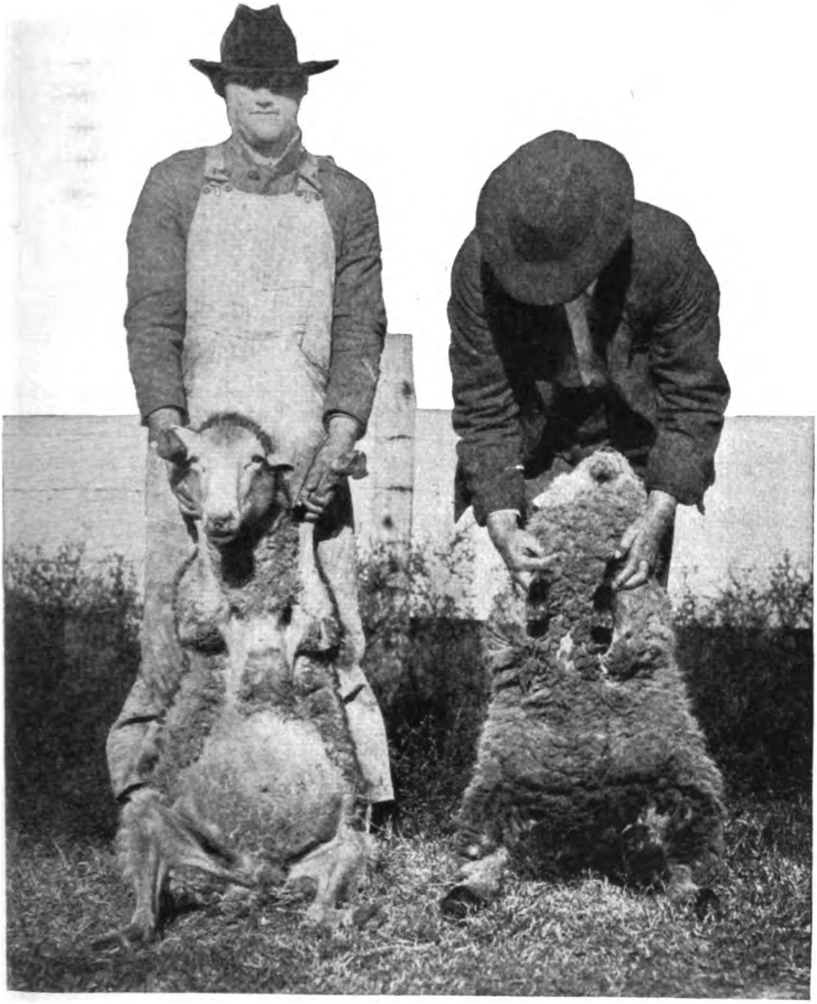
What is the most important part of the pedigree? Usually only the ancestors which are "close up" are those which are of practical importance in determining the identity of the individual. Assuming that Mendel's law governs animal inheritance, we may occasionally expect to find an off-type occurring, but by the repeated culling out of such types the frequency of their occurrence is being constantly reduced. Therefore, if we are sure of the parents and know what is in the first three or four generations of an animal's pedigree, we know the most important facts about that pedigree. In generations beyond the third or fourth the influence of any ancestor is so slight that for practical purposes it may be ignored.



The Main Points of a Pedigree.

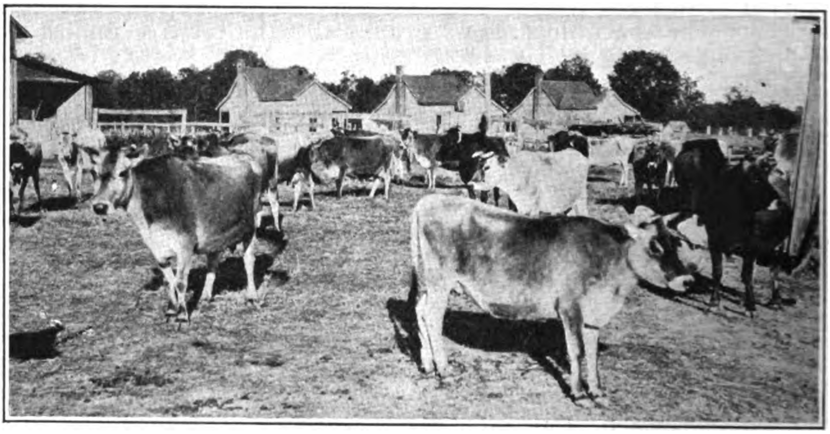
FIG. 19.—A graphic representation of the relative importance of ancestors in the first four generations. Families in livestock often trace their foundation to a single animal which may not be reached within ten generations. It is quite as important to know what sort of animals make up the later matings as it is to know to what family the animal belongs. The proof of the value of a pedigree is the worth of the animals it produces.

In a four-generation pedigree there are 30 ancestors, all of which may be different individuals. Usually in pedigrees of most purebred herds there are fewer than 30 separate individuals, depending on the amount of inbreeding in the pedigree. The chart (fig. 19) shows this fact graphically. Suppose there is no inbreeding in a four-generation pedigree, the chance that one of the animals in the fourth generation will dominate the pedigree above all others is very small indeed. The chart thus shows graphically the relative importance of the respective ancestors for four generations. Each figure in the chart is just half the size of the one in the generation preceding, and this conforms fairly well to the standard formula of inheritance.



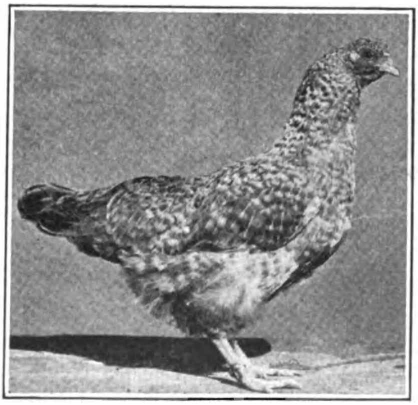
Grading Up With Sheep.

FIG. 20.—The ewe at the left is a Mississippi Piney-Woods native. The lamb is her produce by a purebred Shropshire buck. At four months of age the lamb outweighed not only her mother but any other ewe in the flock. Note the absence of wool on the belly of the ewe and the good, thick, uniform fleece of the lamb.



'Grading Up With Dairy Cattle.

Fig. 21.—The result of 15 years' consistent work with purebred bulls. A Mississippi grade Jersey herd bred up from a native foundation.



Value of Pure Blood.

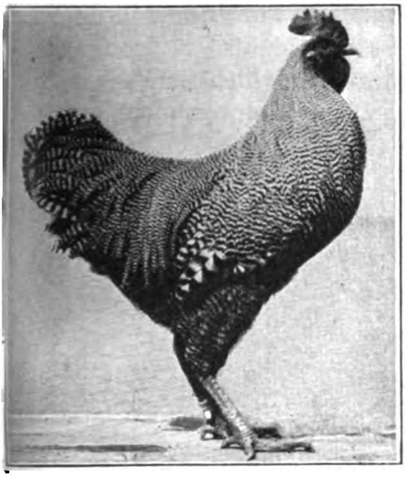
Fig. 22.—In 1915 the Bureau of Animal Industry purchased on the Washington (D. C.) market a flock of mongrel hens. These hens were mated to standardbred males to show how mongrel flocks could be improved by grading up. This illustration shows a mongrel hen, and the four which follow show the results of the demonstration with purebred Barred Plymouth Rock males.

The chance of grandparents' dominating the inheritance of the mating can not be more, and is undoubtedly much less, than 1 in 6; the chance of a great-grandparent is less than 1 in 14; and the chance of a great-great-grandparent (fourth generation) is less than 1 in 30, provided no inbreeding occurs. In a pedigree covering 10 generations (which can easily be run out with almost any of our well-established breeds of domestic animals) there are 2,046 ancestors, more than half of which are in the tenth generation. Yet cattle are sometimes sold at a premium because a certain cow appears in the pedigree as far back as the tenth generation or even further, regardless of the merit of animals much further down in the pedigree. Or a pedigree may be classed as unfashionable and the animal carrying it may be discriminated against, regardless of its individual excellence, because some unpopular animal may have appeared in an extremely remote generation.

LIVESTOCK IMPROVEMENT.

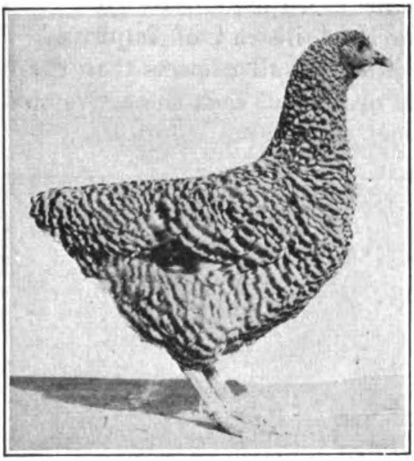
GRADING UP.

The process of improving native stock by breeding the females to purebred males is termed grading up. The first cross is usually a very noticeable improvement over the native stock. When the females of this mating are bred to a male of the same breed, greater



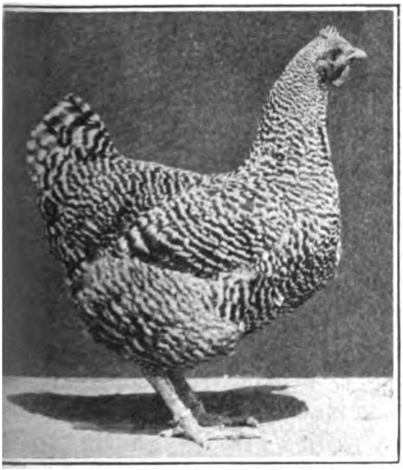
Value of Pure Blood.

FIG. 23.—Barred Plymouth Rock male used for the first cross on mongrel hens such as the one shown in the preceding illustration.



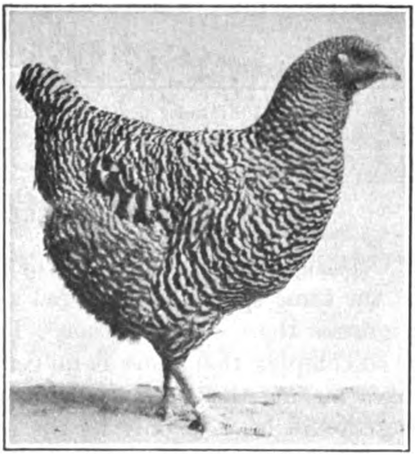
Value of Pure Blood.

FIG. 24.—First-cross pullet of mongrel hen shown in figure 22 and sired by male shown in figure 23.



Value of Pure Blood.

FIG. 25.—Second-cross pullet. Size, conformation, and color of pattern have been greatly improved.

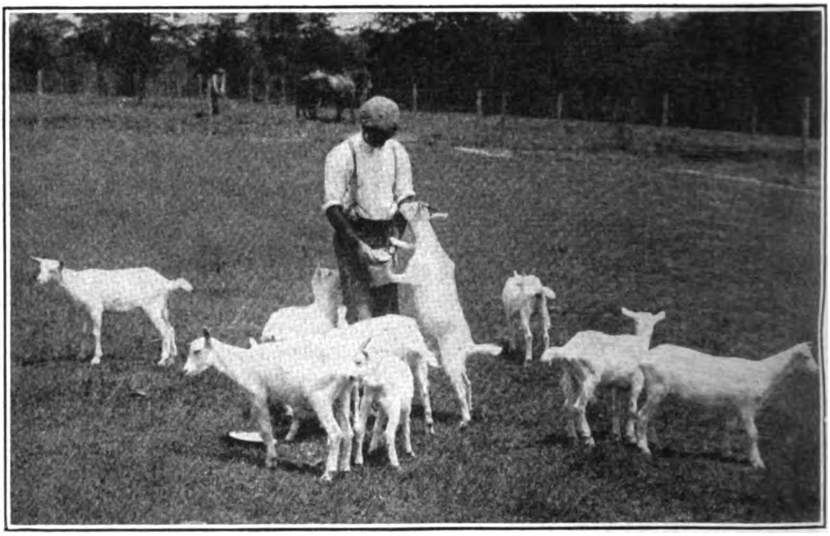


Value of Pure Blood.

FIG. 26.—Third-cross pullet. Fanciers who did not know how she was bred would call this pullet a good representation of the breed.

fixity of type appears. Continued use of males of the same breed results, in a comparatively short time, in animals which are practically purebred, although not eligible to registration and therefore not salable as purebreds.

In grading up, consistent methods should be used and males of the same breed used, cross after cross; otherwise the stock will be mongrelized instead of improved. Males should also be better individuals in all respects than the females with which they are mated, in order that each successive cross may be an improvement over the ones which went before it.



Uniformity Quickly Obtained by Use of Purebred Males.

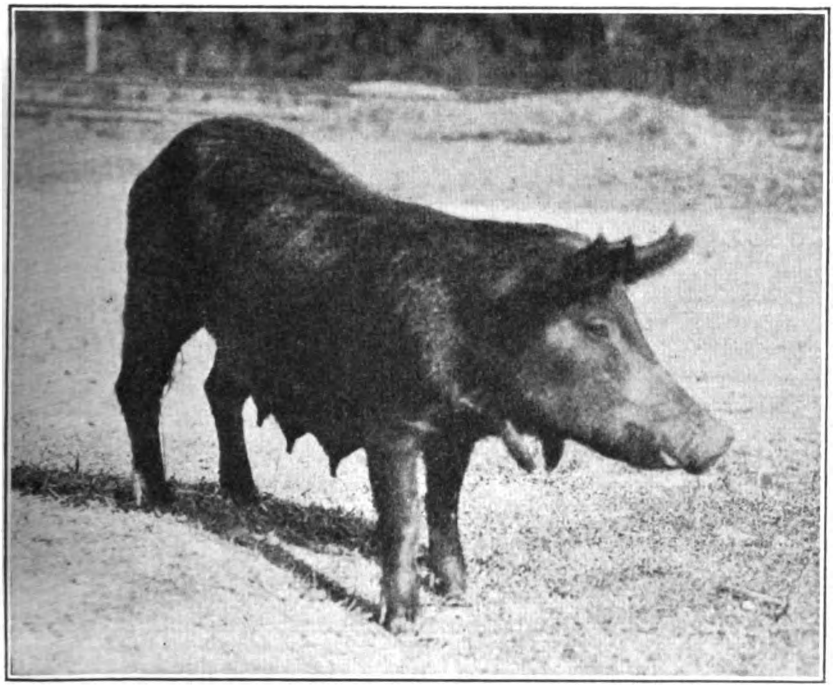
FIG. 27.—Kids at the Experiment Farm of the Bureau of Animal Industry, Beltsville, Md., by purebred Saanen bucks on foundation of native does.

CROSSBREEDING.

Crossbreeding is the mating of purebred animals of different breeds of the same species. Crossbred animals are usually larger and more vigorous than either parent. Their hereditary material, however. is so complex that there is no certainty as to what results will come from mating them. Except to produce market animals, crossbreeding should be used only by the highly skilled breeder, and it is not practicable in his case unless he has an opportunity to place the progeny on the market for breeding purposes. American practice in livestock breeding does not encourage the development of new breeds except in the case of poultry and pet stock. Therefore the practical man, as a rule, will leave this matter to the experimentalists.

SOME INCORRECT IDEAS OF HEREDITY.

From the earliest beginnings of rational mental processes human beings have asked the question "Why?" Failing to receive an answer concerning things which they could not understand they have theorized and developed explanations as a result of such theories which often have not had any basis in fact. From the time when the simple shepherds of Asia watched their flocks beneath the stars and wondered at the mysteries of nature around, above, and beneath them, man has marveled at the mysteries of heredity. In some form or other many of these meditations have persisted until modern times as beliefs for which no unassailable proof has ever been presented.



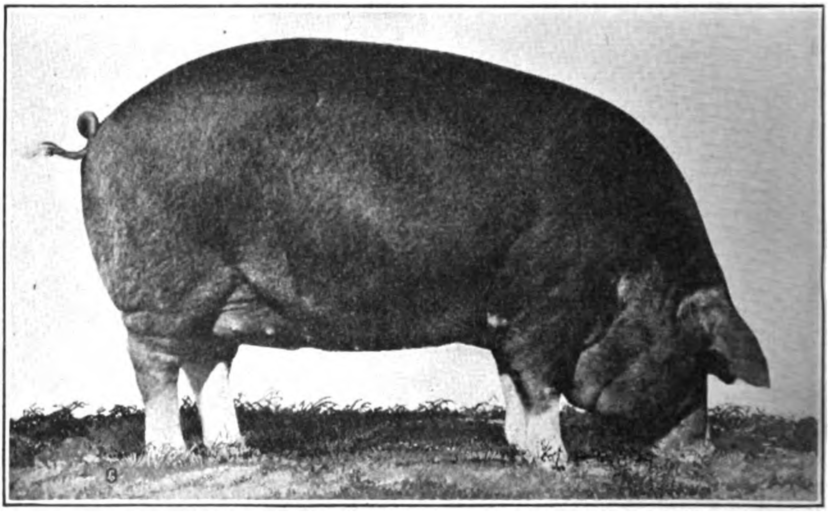
A Fast-Disappearing Type.

FIG. 28.—Native Piney-Woods sow. Note the wattles. These sows are prolific, good milkers. and good mothers. In other respects they have nothing to commend them. Purebred sows are just as prolific, just as good milkers and mothers, and make pork far more rapidly and more economically.

TELEGONY.

These beliefs are sometimes intensified by an apparent confirmation from scientific sources. Possibly the most outstanding instance of this kind is the famous case of Lord Morton's mare, which in the opinion of the great Charles Darwin confirmed the theory of telegony.

This theory was that the first male to impregnate a female permanently endowed the female with his characters, so that subsequently she would always exhibit them in her progeny. If this male was of another breed the female became a crossbred by means of this first impregnation. The Lord Morton mare was a Thoroughbred; she was mated with a quagga and produced a hybrid foal. She was then mated to a Thoroughbred stallion and produced a foal with stripes. In spite of the fact that Darwin knew that frequently horses had both shoulder stripes and leg stripes, and that mules with leg stripes were known to occur, he coupled this Morton case with the erroneous beliefs of dog breeders and gave the theory in question the powerful support of his authority. The theory has been completely disproved by Ewart, who has clearly shown it to have been a manifestation of inheritance. Horses, asses, and other equine stock have a common origin. With our present knowledge of Mendel's law, which was unknown to Darwin, we can understand much more readily that the appearance of stripes in horse stock is more likely due to the unexpected appearance of a recessive character than to any residuary effect of any impregnation on the chromosomes of the female germ cells. Such a theory is utterly impossible if we accept the known facts regarding the chromosomes and their behavior.[7]



Purebred Poland China sow.

FIG. 29.—Contrast this picture with the photograph of the Piney-Woods sow.

Crosses most readily demonstrate the operations of Mendelism, and the more violent the cross the more astonishing are the results. It often happens that the cross of ass and mare brings to the surface characters common to the horse ancestors of the distant past. Another interesting case is seen in crossing certain breeds of hogs, resulting in young which have the longitudinal stripes characteristic of the young wild boar.

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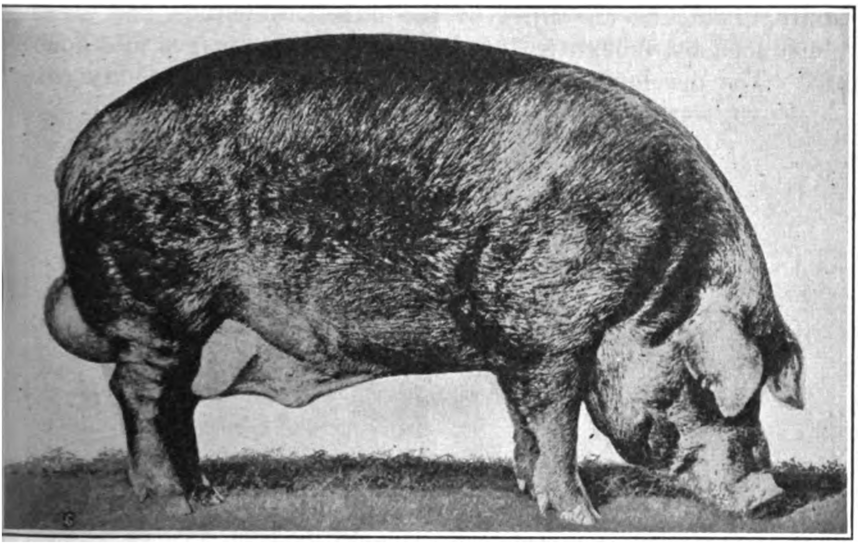
[7] See pages 5–8.

MATERNAL IMPRESSIONS.

A famous ancient classic is the bargain which Jacob made with his father-in-law Laban, and since its historic consummation some breeders of cattle have believed that the presence of objects of striking form or color before the eyes of the female at the time of conception have an influence on the characteristics of the progeny. So far as the Biblical case is concerned, the writer's impression is that Laban was not so skilled in the animal husbandry of his day as was his crafty son-in-law, and judging by what we know to-day of the livestock of Palestine, it would have been far more remarkable if a large proportion of the calves had not been speckled and spotted.[8] A much more modern case is that of McCombie, of Tillyfour, one of the early Scotch improvers of Aberdeen-Angus cattle, who is reported to have believed that he could increase the proportion of black cattle in his herd by having his barns and fences painted black. The red color was comparatively common among Angus cattle a hundred years ago, and breeders were constantly culling out that color. From what we now know of the action of the chromosomes, it was selection and not the color of McCombie's barns that made the Angus cattle "black and all black." Even to-day an occasional red Angus calf appears, as we would expect to happen according to the Mendelian



Purebred Duroc-Jersey boar.

FIG. 30.—Quick results can be obtained by using such males on native sows, or an investment may be made in one or two purebred sows, from which an entire herd of purebreds is soon at hand.

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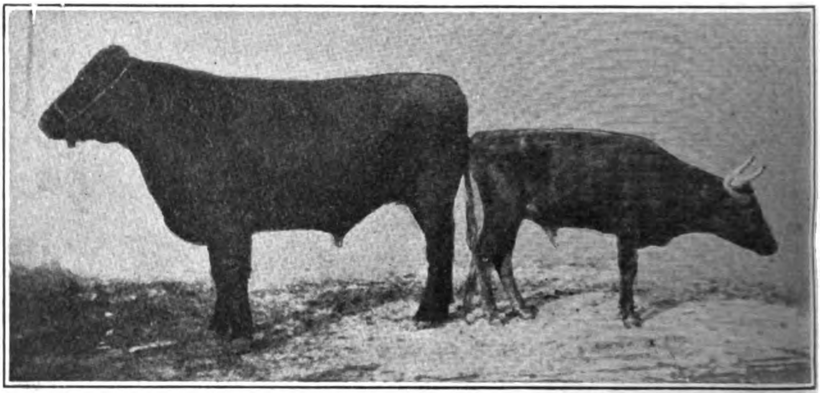
[8] See Genesis xxx : 25–43.

law of inheritance. If the color before the cow's eyes at the time of service had anything to do with the color of the calf, the red barns of the Corn Belt would long since have had an astonishing effect on our American Angus cattle.

Even monstrosities in animals are probably the appearance of some long-submerged character, brought up out of the stream of inheritance by some peculiar combination of the hereditary elements. Certain animals and certain strains produce monstrosities more often than others. Many of these can be brought out readily by intensive inbreeding.

The pregnant mother, whether of the human or of the animal family, should be an object of the utmost solicitude and should receive the most thoughtful, tender care. She is engaged in a double duty. The development of the young creature in her body taxes both bodily strength and nervous organization. We must not forget, however, that there is no direct connection of circulation or nervous system between the mother and the fetus. Therefore the fetus can not be affected by what the mother sees or hears. Accidents to the mother, however, such as sudden strains, falls, etc., may have effects resulting in the serious injury or death of the young. These, again, are not due to heredity, no matter what the effect on the young may be.



How Good Breeding Affects Size.

FIG. 31.—The large animal is a yearling Aberdeen-Angus steer. The smaller one is a three-year-old Piney-Woods steer. The difference between the two is due almost entirely to difference in breeding.

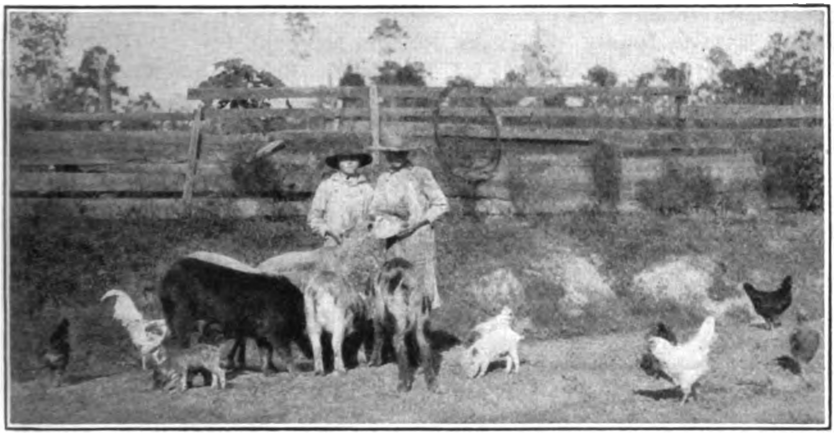
CONCLUSIONS.

The writer does not presume by any means to believe that his effort will succeed in removing completely from the minds of men their fallacious beliefs concerning animal inheritance, but he does hope that he may have some influence in causing those who breed animals to look more to nature herself and to the operation of her laws for the explanation of the facts which they observe and not try to explain them as due to supernatural causes. To summarize very briefly, let us bear in mind the following fundamental facts:

1. All animal forms on the earth have developed gradually from lower forms by very slow changes. This is the process known as evolution.

2. The young animal starts on its career when two bits of hereditary material (germ plasm) unite, one from the female (the egg) and the other from the male (the sperm). When the union is complete, the sex, identity, and individuality of the animal are settled. Chance plays a most important part in determining these factors.

3. From now on the fate of the animal depends on its nourishment and environment.



Why Cloud a Boy's Dreams With This Kind of Stock?

FIG. 32.—Give the youngsters well-bred pigs, calves, sheep, and chickens, and they will be much more likely to stay on the farm and become producers of useful, profitable animals to the advantage of their own pocketbooks and the wealth of the Nation.

4. The breeder can do much to bend the operations of the laws of chance to his own ends by careful selection of breeding stock. "Breed the best to the best."

5. Next to selection the best means at the command of the breeder to fix type in his animals is inbreeding. It is a powerful tool, but a dangerous one in unskillful hands. Inbred sires are more impressive as a rule than sires which are not inbred.

6. Nature does not work lawlessly. Occurrences attributed to supernatural means can be more rationally explained as a manifestation of some operation of a law of heredity.

If a breeder has a clear conception of these facts, he can usually explain by one or the other nearly every occurrence which he may observe. The clearer he thinks on these subjects the more successful he will be as a breeder.

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UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN—1168
UNITED STATES DEPARTMENT OF AGRICULTURE

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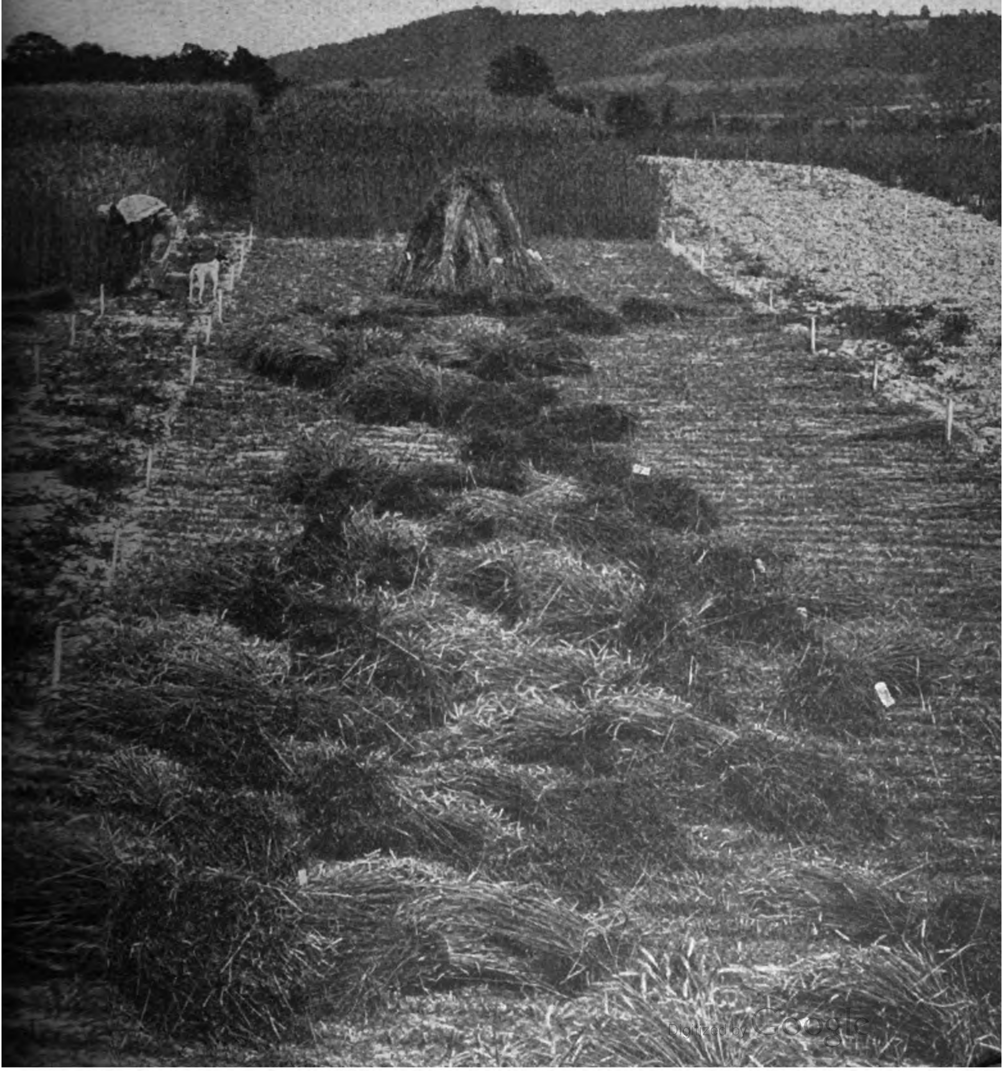
VARIETIES OF WINTER WHEAT ADAPTED TO THE EASTERN UNITED STATES



THE PROFITABLE PRODUCTION of wheat in the eastern half of the United States depends to a considerable extent on the choice of the best adapted varieties. In general, the soft red winter wheats are grown, although soft white wheats are popular in the northeastern United States, especially in New York and Pennsylvania. In the extreme western portion of the area discussed in this bulletin, which is limited on the west approximately by the line of 30-inch rainfall, hard red winter wheats of the Turkey type are grown. Along the line of 30-inch rainfall there is a transition zone in which hard red and soft red winter wheats succeed about equally well. This is especially true of eastern Oklahoma and eastern Kansas.

The leading varieties of hard red winter wheat are the Turkey, Crimean, Kanred, Kharkof, and Malakof. These varieties are widely grown in the western half of the United States.

There are many varieties of soft red wheat, but the most important types are represented by the Fultz, Poole, Fulcaster, and Mediterranean.

The Dawson Golden Chaff and Gold Coin, under different names, are the most important white wheats.

Contribution from the Bureau of Plant Industry
WILLIAM A. TAYLOR, Chief

Washington, D. C. April, 1921

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VARIETIES OF WINTER WHEAT ADAPTED TO THE EASTERN UNITED STATES.[1]

Clyde E. Leighty, *Agronomist in Charge of Eastern Wheat Investigations.*

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THE GEOGRAPHIC REGION COVERED.

THIS BULLETIN deals principally with the soft red and soft white winter wheats adapted to the eastern half of the United States. It is necessary, however, in discussing the kinds of wheat grown in certain States in this section to deal to some extent with the hard red winter wheats and the spring wheats, as there are districts in which these types of wheat may be grown along with those previously mentioned. In other words, transition zones between the different wheat-growing districts exist, where either of two types of wheat may do about equally well.

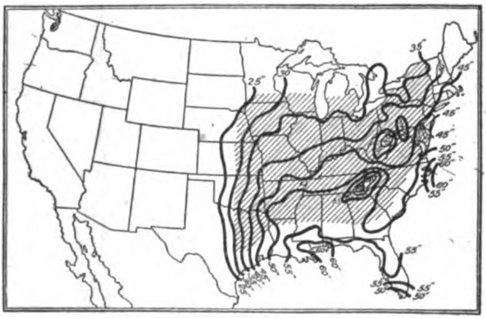

FIG. 1.—Outline map of the United States, showing by shaded lines that portion of the humid wheat region in which winter wheat is now grown. The boundaries are somewhat arbitrary, there being transition zones on the north and west. The average annual rainfall in inches is shown by the numbered lines.

The section of the United States under consideration (the shaded portion of fig. 1) comprises mainly the States east of Nebraska, Kansas, Oklahoma, and Texas and a small eastern portion of each of the four States mentioned. In nearly all of this area the average annual rainfall is at least 30 inches, and, although large seasonal variations occur, the area is generally considered as humid. The average annual rainfall in inches is shown by the numbered lines in figure 1.

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[1] This Farmers' Bulletin supersedes No. 616, entitled "Winter-Wheat Varieties for the Eastern United States," issued in 1914.

Many varieties of wheat are being grown at the present time by the farmers of this part of the United States, and new varieties are continually being originated and distributed by public or private agencies. The same variety is often known by two or more names, however, and the number of distinct varieties is much smaller than the long list of varietal names would indicate. The number of distinct varieties, nevertheless, is large, although the characters which distinguish them are often minute and sometimes not related to the characters which make the varieties valuable. Careful study and considerable time are required in order to learn to recognize varieties, and comparative tests are necessary to determine their value.

TESTING VARIETIES OF WHEAT.

The testing of varieties of wheat has always been an important work of the State agricultural experiment stations and of the United States Department of Agriculture. In such tests usually a large number of varieties are grown under conditions as nearly alike as possible, for the purpose of determining the varieties best suited to local conditions.

It usually has been impossible, however, to find any one wheat which is always best for a given locality, as conditions of climate and soil cause fluctuations from season to season. About the best that can be hoped for is to determine several of the varieties which will do well on the average for several seasons. The variety which gives the best average yield is usually the one that should be grown, and not one that yields remarkably well, perhaps, in one season out of many, but whose average yield is low. The recommendations made in this bulletin are based principally upon the results of varietal experiments made by the State agricultural experiment stations or the agricultural colleges. The assistance given by the agronomists of the States concerned in furnishing these results is hereby gratefully acknowledged.

NORTHWARD ADVANCE OF WINTER WHEAT.

Since the introduction of the hardy varieties of wheat from southeastern Europe there has been a decided northward movement of the winter-wheat area. This movement has been rapid in recent years. The reasons therefor are the generally large yields of winter wheat, due (1) to its earlier maturity, thus enabling it to escape hail, hot winds, and disease; (2) to its greater drought resistance; and (3) to the better division of labor which it allows, through fall seeding and earlier harvesting.

The acreage of winter wheat in 1909 is shown in figure 2 and the same data for common spring wheat in figure 3.

The average yields in Iowa and Minnesota for 10 years (1909–1918) show an advantage of 4.2 and 3.1 bushels, respectively, in favor of winter wheat over spring wheat. With this evidence at hand it is seen that the region in which winter wheat is grown should be extended northward as rapidly as possible, making use of the hardy varieties and more hardy strains as these are developed, and that the spring varieties should be used only in cases where the fall-sown wheats are winterkilled or where winter-wheat growing has been found by trial to be unprofitable. Large acreages of winter wheat should not be sown in any locality, however, until it has been determined by tests lasting at least three years that the crop will succeed.

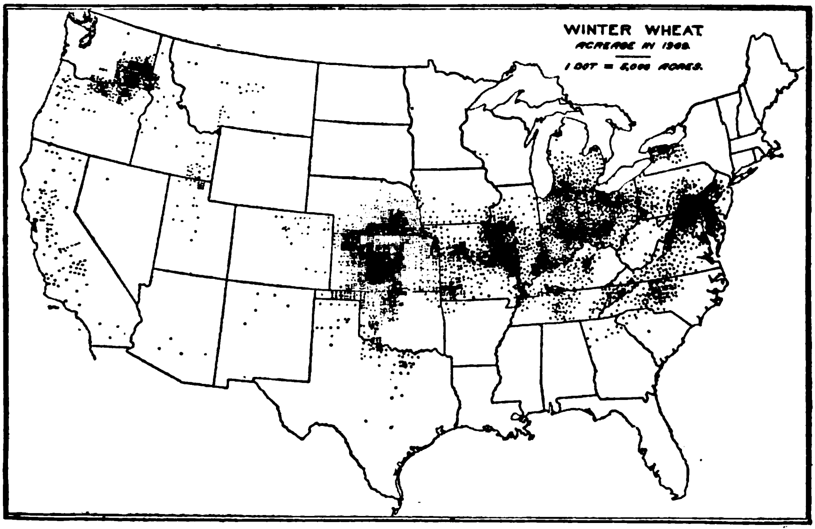

FIG. 2.—Outline map of the United States, showing the acreage of winter wheat grown in 1909. Each dot represents 5,000 acres. Each county having over 2,500 acres and not more than 7,500 acres has one dot, from 7,500 acres to 12,500 acres, two dots, etc.

TRANSITION ZONES IN WHEAT GROWING.

In northern Iowa and southern Minnesota there is a transition zone between the district which grows only winter wheat and the district which grows only spring wheat. In this zone both spring and winter wheats are grown, often on the same farm. This same condition exists in northeastern Nebraska.

In southern Iowa, southeastern Nebraska, eastern Kansas, central Oklahoma, and north-central Texas there is a similar transition zone, the two types of wheat being the hard red winter wheats of the Turkey type, that are better adapted westward, and the soft red winter wheats, that are better adapted eastward. This transition zone, generally speaking, is that region which has an average annual rainfall between 30 and 35 inches.

HARD RED WINTER WHEAT.

The hard red winter wheats are of the Turkey or Crimean type, represented principally by the Turkey, Crimean, Kanred, Kharkof, and Malakof varieties. All of these are usually adapted to localities in which the Turkey variety succeeds. The Kharkof is generally considered to be more hardy than the Turkey variety and consequently better adapted than the latter to northern localities, especially in the northern parts of Illinois, Iowa, and Nebraska and the southern parts of Minnesota and Wisconsin. Certain selected strains of the Turkey wheat seem to be, however, equally as hardy as the Kharkof. There are also strains of these hard wheats, selected at several State experiment stations, which yield much better than the unselected seed commonly grown. The Kanred, developed at the Kansas Agricultural Experiment Station, is one of the best of these.

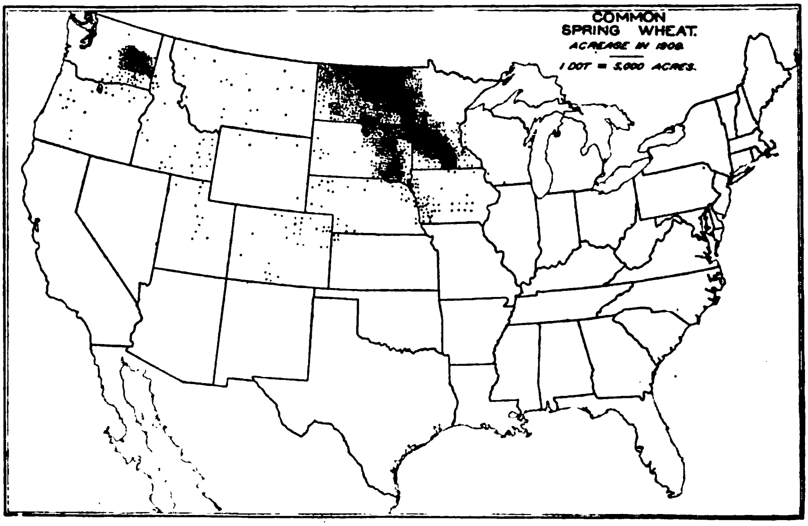

FIG. 3.—Outline map of the United States, showing the acreage of common spring wheat grown in 1909. Each dot represents 5,000 acres. Each county having over 2,500 acres and not more than 7,500 acres has one dot, from 7,500 acres to 12,500 acres, two dots, etc.

SOFT RED WINTER WHEAT.

Soft red winter wheat is sown in all that part of the United States east and south of the transition zone already described where wheat is grown, except those parts of the North Atlantic and New England States where white wheat or spring wheat is grown. This region is sometimes divided into northern and southern sections; but this division is based upon climatic conditions, as the grain produced in the Southern States is not markedly different from that produced in the Northern States.

For convenience of reference only, the States producing red winter wheat will be grouped under the following heads:

(1) The southern section west of the Mississippi River, which includes eastern Oklahoma, Arkansas, Texas, and Louisiana.

(2) The southern section east of the Mississippi River, which includes Tennessee and North Carolina and the States southward.

(3) The North-Central States, which include Kentucky and the States northward; also Missouri and part of Kansas.

(4) The North Atlantic States, which include Virginia and the States northward.

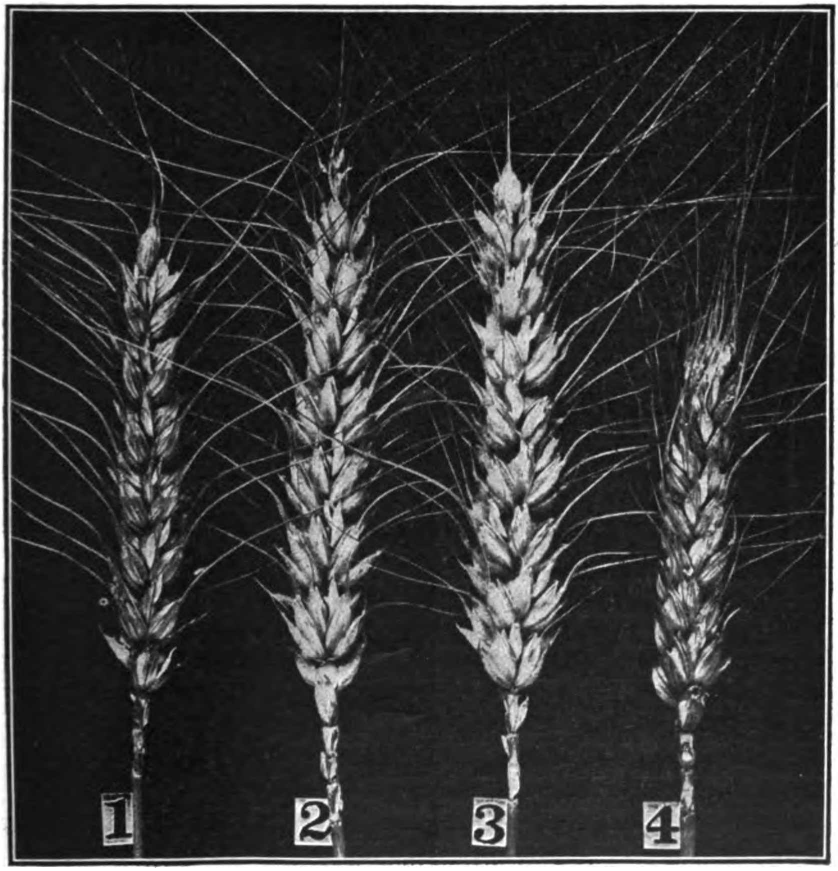

FIG. 4.—Heads of bearded winter wheat, representative of the following groups: 1, Mediterranean (group 6); 2, Virginia (group 7); 3, Bearded Winter Fife (group 13); 4, Early Genesee Giant (group 12).

ADAPTED VARIETIES OF SOFT RED WINTER WHEAT.

WHEAT IN THE SOUTHERN SECTION WEST OF THE MISSISSIPPI RIVER.

Texas.—For the northern part of Texas, extending southward three or four tiers of counties from the Red River, where the annual rainfall amounts to about 30 inches or more, bearded wheats of the Mediterranean type (fig. 4) are commonly grown and give on the average better results than the Turkey wheats. In addition to the Mediterranean variety, the Fulcaster and the Ironclad are varieties of soft red bearded wheats commonly grown, while the Poole, Michigan Amber, and German Emperor (all very similar to each other) are good soft red beardless wheats. The area to the west, where the rainfall is less than about 30 inches annually, is included in the hard winter-wheat district, and the Turkey and Kharkof varieties are more certain to produce a good crop. Wheat is not successfully grown on the sandy coastal plains of Texas.

Louisiana.—Wheat has generally failed when grown for grain in Louisiana, and it can not be recommended. On the red lands of northern Louisiana, however, wheat is one of the best winter grazing crops and in favorable seasons may produce a profitable yield of grain. As it fits well in systematic rotations, wheat may often be grown profitably in Louisiana for pasture and feed. The following varieties of soft red winter wheat are reported as having yielded well: Fultz, Red May, Harvest King, Fulcaster, and Purple Straw. Of these varieties the Fulcaster is bearded, while the others are beardless.

Arkansas.—Conditions for wheat growing in southern Arkansas are similar to those of northern Louisiana. On the high lands of the northern part, however, wheat may be more successfully grown. The varieties giving the best results are the Alabama Bluestem, Red May, Purple Straw, and Fultz, all beardless varieties, and the Fulcaster and Stoner[2] (or Marvelous), bearded varieties.

Oklahoma.—There are two distinct wheat belts in Oklahoma. The western portion, which is the main wheat section, is in the hard red winter-wheat belt, while the eastern portion is in the soft red winter-wheat belt. The division line lies about midway between the lines of 30 and 35 inch average annual rainfall (see fig. 1) and coincides roughly with the 1,000-foot elevation line. A line drawn from Newkirk in the north to Waurika in the south divides the State approximately into the two portions. Along this line both hard and soft wheat varieties succeed about equally well on the average, although one or the other may be favored by seasonal conditions.

The hard wheats adapted to the western portion are the Turkey, Kharkof, and Kanred, all bearded. The Kanred has led in yield in recent varietal experiments. The soft red wheats adapted to the eastern portion are the Sibley New Golden, Fulcaster, Missouri Bluestem, and Mediterranean (all bearded varieties), and the Fultz and Early Red Clawson (beardless varieties).

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[2] This variety is known by various other names, among which are Miracle and One-Peck-to-the-Acre. Extravagant and misleading claims have been made for it, concerning which detailed data are given in Department Bulletin 357. It should be sown at the rate per acre commonly used for wheat and not at reduced rates.

WHEAT IN THE SOUTHERN SECTION EAST OF THE MISSISSIPPI RIVER.

Mississippi, Alabama, Georgia, and South Carolina.—Wheat is more successfully grown on clay or loam than on sandy soil; consequently it is not grown to any large extent in the southern parts of these States, but is principally confined to the Piedmont region. Preference should be given to good locally grown seed of a strain or variety that is known to produce good results.

A beardless, white-chaffed, red-grained variety known in different localities as Alabama Bluestem, Georgia Bluestem, Alabama Red, Georgia Red, or Purple Straw is generally one of the best yielding wheats in these States. Other good beardless varieties of wide adaptation are the Red May, Fultz, and Leap Prolific. Bearded wheats usually producing good yields are the Red Wonder, Fulcaster, and Dietz Mediterranean. There is little, if any, difference between the wheats to which these three names are applied.

Florida.—Wheat is seldom grown in Florida and can not be recommended as a crop for that State. Occasionally it produces a fair yield of grain, but it is not a sure crop and can not compete with other crops.

Tennessee.—Much of Tennessee is fairly well suited to wheat growing, the yields and quality of grain being good. The Fulcaster, Poole, Fultz, and Fultzo-Mediterranean (known also as Economy, New Columbia, Squarehead, and Four-Rowed Fultz) varieties are recommended. All of these are beardless except the Fulcaster, which is bearded. With the Fulcaster may be included the Stoner or Marvelous[3] variety. Other red-grained varieties that have done especially well in comparative experiments are the Kansas Mortgage Lifter, Dietz, Mediterranean, and Valley (all bearded) and the Currell Prolific, Red Russian, Harvest King, and Red Prolific, beardless sorts. The Fultzo-Mediterranean has stiff straw and is therefore recommended for rich land where other varieties may lodge.

North Carolina.—The Piedmont and mountain sections of North Carolina are suited to wheat growing. The Purple Straw, Leap Prolific, Red May, and Fultz (beardless varieties, fig. 5), and the Fulcaster, Lancaster, Dietz, and Red Wonder (bearded varieties) are some of the well-known sorts which have given good yields in this State.

WHEAT IN THE NORTH-CENTRAL STATES.

Eastern Kansas.—The soft or semihard wheats, known commercially as soft red winter wheat, are best for growing in a section of eastern Kansas. This section can not be limited exactly, but may be said to include the eastern tier of counties at the north and, gradually increasing toward the south, to include the four eastern tiers on the southern border. The line of division is not far from the 35-inch rainfall line shown in figure 1. In a section west of this, including one or two tiers of counties across the State and approaching well toward the 30-inch rainfall line, soft red and hard red wheats do about equally well. This is the transition zone between these two types of wheat, as the hard wheats of the Turkey type undoubtedly are better west of this zone.

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[3] See the footnote on page 8.

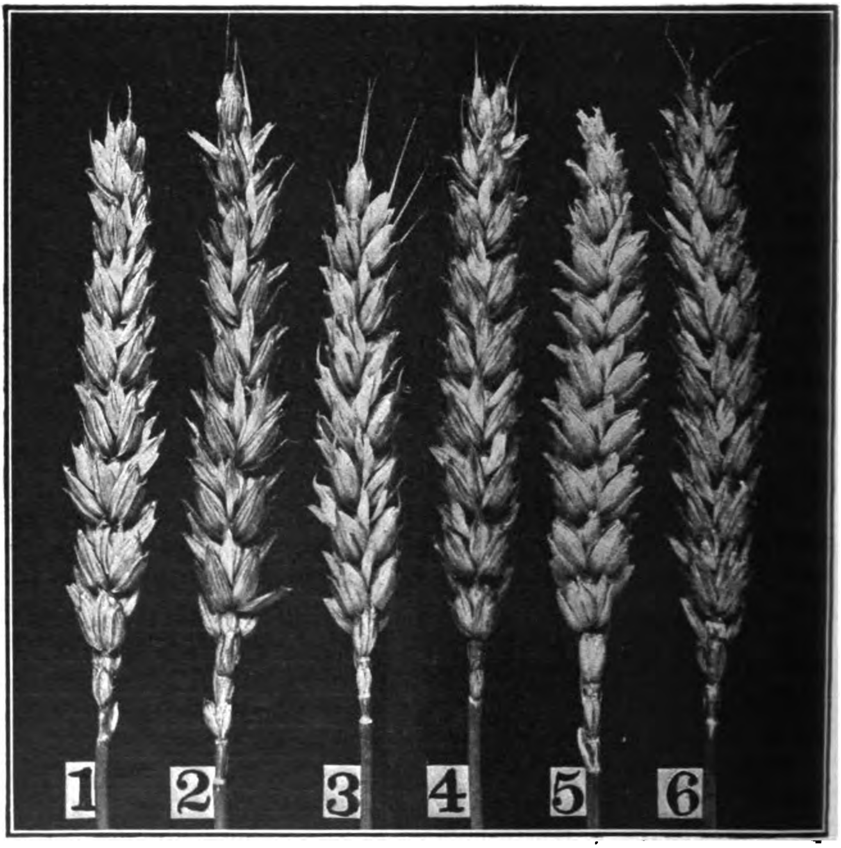

FIG. 5.--Heads of beardless winter wheat, representative of the following groups: 1, Fultz (group 1); 2, Leap Prolific (group 1); 3, Purple Straw (group 1); 4, Poole (group 2); 5, Mealy (group 3); 6, Dawson Golden Chaff (group 10).

The Fulcaster variety has produced the highest yields in experiments conducted in southeastern and northeastern Kansas to determine the best varieties of wheat. In northeastern Kansas the Harvest Queen has yielded nearly as well as the Fulcaster and is more winter hardy. It also has a stiff straw and stands up well on rich soil. The Harvest Queen is beardless and is therefore given preference by many farmers over the Fulcaster, which is bearded.

The Fultz and Zimmerman, beardless white-chaffed varieties, are often grown in the soft-wheat belt of eastern Kansas. Both are early maturing, the Zimmerman being especially early. In certain seasons and on some soils where earliness is an advantage, these varieties are better than the later maturing ones.

The Currell, a beardless red-chaffed variety, is especially well suited to wet lands in southeastern Kansas. It has a rather stiff straw and stands up well after ripening.

In the transition zone mentioned above and westward, the Kanred, a new variety of hard winter wheat developed at the Kansas Agricultural Experiment Station, appears to be superior to the older varieties, Turkey and Kharkof, which hitherto have been generally grown.

Missouri.—Extensive varietal experiments made by the Missouri Agricultural Experiment Station in recent years, in cooperation with the United States Department of Agriculture, indicate that the bearded varieties, Fulcaster, Dietz (Fulcaster and Dietz are practically identical), Mediterranean, and Lebanon, and the beardless varieties, Poole, Michigan Wonder, Red Wave, Beechwood, Early Ripe (these last-named five varieties are similar), Hickman, and Fultz (Hickman and Fultz are practically identical), are well adapted for growing in that State. The hard red winter wheats, Kanred, Turkey, and Kharkof, are about equal to the soft red varieties named above in the extreme northwestern corner of the State.

Illinois.—The hard red wheats are best adapted to central and northern Illinois. The Kharkof seems best adapted to the extreme northern part, while the Kharkof, Turkey, Malakof, and Beloglina are all adapted to the remainder of this section.

The soft red wheats are best adapted to southern Illinois. The following varieties are among the best for this part of the State: Fulcaster and Rudy (bearded varieties), and Harvest King, Wheedling, Fultz, and Poole (beardless varieties).

Kentucky.—The Fultz has not been surpassed in yield by any variety tested at the Kentucky Agricultural Experiment Station, and it is probably the equal of any variety for the bluegrass section of the State. A strain of this wheat isolated and tested at the Kentucky station has been found better than the original variety, and this will soon be distributed over the State. The Fultzo-Mediterranean (also known as Square-Head, Four-Rowed Fultz, and Economy), because of its stiff straw, is suited to very rich land, especially bottom land. The Currell Prolific and the similar varieties Poole and Harvest King are considered by farmers as best in western Kentucky.

Of the bearded wheats the Fulcaster is a high yielder and produces grain of excellent quality. The Kansas Mortgage Lifter and Marvelous are practically identical with the Fulcaster.

Indiana.—Extensive experiments conducted by the Purdue University Agricultural Experiment Station indicate that the Michigan Amber, Harvest King, Rudy, Farmers Friend, and the better strains of Fultz and Poole are well adapted to the greater part of the State. The Turkey is a good variety for the black soils of the northwestern section of Indiana. The Red Wave is a good yielder in certain sections, but as a rule is not of good milling quality. These are all red wheats. The Rudy, Farmers Friend, and Turkey are bearded varieties, while the others mentioned are all beardless. In some sections the Red Rock (bearded) is finding favor. Several other varieties are to be found in the State. The varieties named are among the best and most widely distributed, however, and may be safely recommended.

Ohio.—In a 20-year varietal experiment at the Ohio Agricultural Experiment Station the Dawson Golden Chaff has led in yield by slightly more than a bushel per acre. This wheat, it must be remembered, however, is not a red but an amber or white grained wheat. Red wheats following closely in yield are Harvest King, Nigger, Poole, Mealy, and Valley. In the past 10 years a number of new varieties of red wheat originated by selection at this station have been included. The white wheats Dawson Golden Chaff and Gold Coin have again led in yield, but by less than a bushel per acre. In this 10-year experiment the highest yielding red wheats are the Gladden (a selection of Gipsy), Portage (a selection of Poole), Trumbull (a selection of Fultz), Harvest King, Red Wave, Poole, and Nigger. Tests made in different parts of the State indicate that the selections named above are widely adapted. The Gladden, Nigger, and Valley are bearded; the others are beardless.

Michigan.—The Red Rock (bearded, red grained, red chaffed) is the most widely grown variety in Michigan. It was developed at the Michigan Agricultural Experiment Station. When grown on good wheat land it produces grain of superior hardness and baking qualities. The Egyptian, Nigger, Shepherd Perfection, and Lancaster are old standard varieties which came through the trying winters of 1917 and 1918 in comparatively good shape.

Of the white wheats the American Banner is of the highest quality, but the Dawson Golden Chaff, Gold Coin, and Plymouth Rock are more widely grown.

Due to the increase in the milling of local wheats there is an increased demand for red wheats of superior hardness as compared to the softer red and white wheats.

In 1918 and 1919 the acreage of spring wheat was largely increased in Michigan. The Marquis variety has met with most widespread favor. Judging by the performance of this variety during the past two years a considerable acreage of spring wheat will figure permanently in many Michigan sections, particularly in the Thumb region, the upper part of the Lower Peninsula, and on land adapted to wheat on the Upper Peninsula.

WHEAT IN THE NORTH ATLANTIC STATES.

Virginia.—Varieties adapted to the western part of Virginia are the Fulcaster, Stoner, Red Wonder, Blue Ridge, and Mediterranean (bearded varieties), and the Fultz, Harvest King, Leap Prolific, and Perfection (beardless varieties). The bearded varieties have yielded better than the beardless ones. For the northern and eastern parts of the State tests at the Arlington Farm, near Washington, D. C., indicate that the following varieties are all well adapted: Purple Straw, Fultz, Poole, Leap Prolific, Currell, and China. All of these are beardless varieties. The bearded varieties, Dietz, Bearded Purple Straw, and Mammoth Red (all similar), while especially good in some seasons, have not produced as high average yields as the beardless sorts.

West Virginia.—Gipsy, Nigger, and Rudy (bearded, red-grained varieties), Poole (beardless red grained), and Dawson Golden Chaff (beardless white grained) are good varieties for growing in this State.

Maryland.—The following varieties of wheat are adapted to Maryland: China and Currell Prolific (beardless red wheats), Bearded Purple Straw, Dietz Longberry, Turkish Amber, Mammoth Red, and Fulcaster (bearded red wheats), and Dawson Golden Chaff (a beardless white wheat).

Delaware.—The wheats listed below are especially recommended for conditions in this State. They have yielded well in extensive experiments at the Delaware Agricultural Experiment Station and in the main have the characteristics desired by the farmer and by the miller.

The bearded varieties recommended are the Auburn Red, Dietz Amber, Farmers Trust, Gipsy, Lebanon, Mediterranean, Red Wonder, Reliable, Rudy, and Valley. The beardless varieties recommended are the California Red, Currell Prolific, Harvest King, Leap Prolific, and Poole.

New Jersey.—The Fultz, Currell Prolific, and China are good beardless red-grained wheats for New Jersey, and the Dawson Golden Chaff is an adapted beardless white-grained wheat. These varieties have been widely grown and have been found to yield well in nearly every place where tried. The Leap Prolific is a good beardless red-grained wheat for the State for early sowing, but has not been found as satisfactory as some other varieties for late sowing. The Red Wave is also grown to some extent.

The Fulcaster, a bearded red-grained variety, is adapted to a wide range of soils in the State and is one of the surest wheats for northern New Jersey, as it also is for much of the eastern part of the United States. The straw is of medium stiffness, this variety being inferior in this respect to the Fultz, Currell Prolific, and China varieties.

Pennsylvania.—Varieties of red winter wheat adapted to Pennsylvania are the Currell Prolific, St. Louis Grand Prize, Poole, Red Wave, Harvest King, Reliable, Dietz Longberry, and Fulcaster. The last three mentioned are bearded; the others, beardless. Dawson Golden Chaff, a white wheat, gives excellent results in the State.

New York.—White wheats are most commonly grown in New York. Several of the red wheats, however, have yielded well in recent experiments. The Red Wave and Prosperity, beardless varieties, and the Gipsy and Fulcaster, bearded varieties, are recommended. Selections from these varieties developed in the breeding operations at Cornell University Agricultural Experiment Station in cooperation with the United States Department of Agriculture have outyielded the original varieties and are being distributed to farmers.

SOFT WHITE WINTER WHEAT.

The principal district growing soft white winter wheat comprises New York and Pennsylvania and portions of the States lying immediately south and east of them. White wheat is not the only kind grown in this district, red wheat being also largely grown in some parts. On the other hand, more or less white wheat is grown throughout the soft red winter wheat district, especially in Michigan and Ohio.

In New York and under similar conditions, speaking generally, white wheats yield more grain per acre, possess stronger straw, weigh a little less to the measured bushel, have slightly softer grains, and furnish a better pastry flour but a somewhat weaker bread flour than the red varieties.

DEMAND FOR SOFT WHITE WHEAT.

There is a considerable demand for soft white wheat in New York and adjoining States by manufacturers of whole-wheat foods and pastry flours. When the local supply is inadequate, this class of wheat is sometimes brought from the Pacific coast. There is also a large local demand for wheat as poultry feed in these States and in New England, and the variety giving the largest yields of grain will probably be found most profitable where this demand exists, irrespective of the milling value of the wheat. Where white wheat yields best, therefore, and there is a good market for it, the growing of this type is recommended.

ADAPTED VARIETIES OF SOFT WHITE WINTER WHEAT.

The white wheats which have succeeded well in the North-Central and North Atlantic States are as follows:

Indiana.—Dawson Golden Chaff.

Michigan.—Early Windsor, Dawson Golden Chaff, American Banner.

Ohio, Virginia, West Virginia, Maryland, and New Jersey.—Dawson Golden Chaff.

Pennsylvania.—Dawson Golden Chaff, Gold Coin (or Fortyfold, Klondike, or Number 6).

New York.—Dawson Golden Chaff, Gold Coin (or Fortyfold, Klondike, or Number 6), Jones Longberry No. 1, Early Genesee Giant.

Dawson Golden Chaff is probably the leading variety of soft white winter wheat. It has been one of the highest yielding varieties among all the wheats tested in the States just mentioned. This variety stands up well in the field and is above the average in winter resistance. The grains are somewhat harder than those of most other white wheats. In several milling and baking tests that have been made it has given a good yield of flour, rather low in total protein content, but containing gluten of excellent quality.

Gold Coin wheat under one name or another, such as American Banner, Fortyfold, Klondike, Number 6, or Junior No. 6, is grown very widely in New York. It has a somewhat softer, whiter grain than the Dawson Golden Chaff variety, the head is somewhat more compact, and the straw is purple, while in the Dawson Golden Chaff it is yellow.

WHEAT IN THE NEW ENGLAND STATES.

The only States of this group for which wheat production is reported by the Bureau of Crop Estimates are Maine and Vermont. There was a marked increase in acreage and production in these two States from 1914 to 1918, but a decrease in 1919. In Maine the increase was from 3,000 acres in 1914 to 22,000 in 1918, with a decrease to 8,000 acres in 1919. The production in the three years was, in 1914, 81,000 bushels; in 1918, 484,000 bushels; in 1919, 150,000 bushels. In Vermont the area increased from 1,000 acres in 1914 to 19,000 in 1918 and decreased to 11,000 in 1919. The production in the three years was, in 1914, 29,000 bushels; in 1918, 418,000 bushels; in 1919, 176,000 bushels.

Spring wheat is the only kind reported as being grown in the two States just mentioned. The adapted varieties are the Marquis, Fife, Bluestem, and Preston.

Experiments made by the Connecticut Agricultural Experiment Station at New Haven during the seasons of 1911–12 and 1912–13 with seed of 14 varieties of winter wheat furnished by the United States Department of Agriculture indicate that all of the varieties tested can be successfully grown in that locality. Although all these varieties were grown under adverse soil conditions, the average yield for the two years is above 18 bushels in every case. The six leading varieties in the order of yield are Dawson Golden Chaff, Fultzo-Mediterranean, Dietz, Bearded Winter Fife, Fultz, and Maryland Flint. The Dawson Golden Chaff yielded at the rate of 29 bushels per acre, while the other five varieties each yielded approximately 23 bushels per acre. It is probable that the Dawson Golden Chaff is one of the best-yielding winter varieties for the New England States.

There is a large local demand in New England for wheat as a poultry or stock feed. It should not be difficult for several farmers in almost every neighborhood to sell at a good price to their neighbors all the wheat which they can raise. The growing of wheat on land adapted to its culture is therefore likely to prove profitable in New England, and the farmers of this section would do well to consider carefully the addition of wheat to the crops which they grow. Winter wheat will doubtless produce better average yields, where it can be grown, than spring wheat if proper cultural methods are employed and suitable varieties are used.

THE IMPROVEMENT OF VARIETIES.

Many farmers are doubtless growing inferior varieties of wheat. The first concern of every grower should be to determine, by test or otherwise, the variety best suited to his conditions. Having determined this point, he should then begin and faithfully continue systematic efforts to improve this variety for the conditions of his farm. The method of improvement to be adopted should depend upon the importance of the wheat crop on the farm in question and the time and facilities at the disposal of the farmer. Every farmer should at least use clean, plump, heavy seed of the best-adapted variety that he can obtain.

Wheat can be improved in yield and in other desirable characters by the selection of good heads or good plants from the general field and growing the seed from each individual head or plant in separate rows. At harvest time the best rows are thrashed and preserved separately and each lot thus obtained is sown again in separate rows of suitable length. This is continued year after year until a few superior strains are obtained, which may be rapidly increased in larger plats.

A method of purifying a variety and sometimes of increasing yield is one which may be called "mass selection." No great amount of time or extra labor is required by this method to secure satisfactory results. In applying it, a field of wheat is examined at harvest time and enough good heads of the desired type are selected to make a bushel or more of seed. This is thrashed separately and sown in the ordinary way in a field or plat of good fertility. It may be sown in a marked portion of a general wheat field. At harvest time the best heads are picked from the plat sown with the special seed, just as they were picked from the general field the year before, and these heads are handled and sown as were those selected the previous year. The remainder of the plat is cut and thrashed separately, and the grain thus obtained is used as seed for the general crop. This method of selection should be continued year after year as a means of providing good seed of uniform type for the general wheat crop on the farm.

THE GROUPING OF ADAPTED VARIETIES OF WHEAT.

The wheats recommended in this bulletin are grouped below in accordance with some of the most obvious and most easily determined characters. The terms used in the description are red, white, and amber—to denote the color of the wheat kernels; bearded and beardless—to denote the presence or absence of beards on the heads; white or yellow and red or brown—to denote the color of the chaff (no attempt being made to distinguish white from yellow or red from brown); and velvet and smooth—to denote the presence or absence of hairs or velvet covering on the chaff. The following classification is made according to the descriptions most commonly given of the different varieties:

(1) **Red kernels, beardless, smooth white or yellow chaff.**

Hard spring.—Fife (Minnesota No. 163), Marquis.

Soft or semihard winter.—Alabama Bluestem (Alabama Bluestem, Alabama Red, Georgia Bluestem, Georgia Red, and Purple Straw are apparently different names for the same variety), Alabama Red, Fultz (Hickman and Jersey Fultz are other names for this variety), Fultzo-Mediterranean (known also as Economy, New Columbia, Squarehead, and Four-Rowed Fultz), Georgia Bluestem, Georgia Red, Harvest Queen (sometimes known as Red Cross), Hickman, Jersey Fultz, Leap Prolific, Ontario Wonder, Prosperity (other names are American Bronze and Number 8), Purple Straw, Red May,[4] Trumbull, Zimmerman.

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[4] A red or brown chaffed strain is also grown.

(2) Red kernels, beardless, smooth red or brown chaff.

Soft or semihard winter.—Beechwood, California Red, China (known also as Pennsylvania Bluestem), Currell Prolific, Early Red Clawson, Early Ripe, German Emperor,[5] Golden Chaff, Harvest King, Michigan Amber (Michigan Amber, Michigan Wonder, Early Ripe, and one strain of Red May are apparently the same variety), Michigan Wonder, Perfection, Poole, Portage, Red Prolific, Red Russian, Red Wave, Rochester Red, Wheedling.

(3) Red kernels, beardless, velvet white or yellow chaff.

Hard spring.—Bolton Bluestem, Haynes Bluestem, Minnesota No. 169 (selection from Haynes Bluestem).

Soft or semihard winter.—Mealy, Jones Winter Fife.

(4) Red kernels, beardless, velvet red or brown chaff.

Soft or semihard winter.—St. Louis Grand Prize.

(5) Red kernels, bearded, smooth white or yellow chaff.

Soft or semihard winter.—Auburn Red, Bearded Purple Straw, Budapest, Dietz (or Dietz Longberry), Egyptian Amber, Farmers Friend, Fulcaster, Gladden, Grains o' Gold, Gipsy, Ironclad, Kansas Mortgage Lifter, Lebanon, Mammoth Red, Marvelous,[6] Nigger, Red Wonder,[7] Reliable, Rudy, Sibley New Golden, Stoner,[6] Turkish Amber, Valley, Winter King.

Hard winter.—Beloglina, Crimean, Kanred, Kharkof, Malakof, Turkey.

Hard spring.—Early Java, Preston (known also as Velvet Chaff and Johnson).

(6) Red kernels, bearded, smooth red or brown chaff.

Soft or semihard winter.—Blue Ridge, Diehl Mediterranean, Farmers Trust, Lancaster, Mediterranean, Missouri Bluestem, Red Rock, Shepherd Perfection.

(7) Red kernels, bearded, velvet white or yellow chaff.

Soft or semihard winter.—Rural New Yorker No. 57, Virginia.

(8) Red kernels, bearded, velvet red or brown chaff.

Soft or semihard winter.—Velvet Chaff.

(9) White or amber kernels, beardless, smooth white or yellow chaff.

Soft winter.—Early Ontario, Kentucky Bluestem.

(10) White or amber kernels, beardless, smooth red or brown chaff.

Soft winter.—American Banner, Early Windsor, Dawson Golden Chaff, Gold Coin (apparently the same as American Banner, Fortyfold, Klondike, or Number 6), Plymouth Rock.

(11) White or amber kernels, bearded, smooth white or yellow chaff.

Soft winter.—Seneca Chief.

(12) White or amber kernels, bearded, smooth red or brown chaff.

Soft winter.—Early Genesee Giant, Jones Longberry No. 1.

(13) White or amber kernels, bearded, velvet white or yellow chaff.

Soft winter.—Bearded Winter Fife.

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[5] A white-chaffed strain is also grown.

[6] See footnote on page 8.

[7] A red-chaffed strain is also grown.

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UNITED STATES DEPARTMENT OF AGRICULTURE

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INSECTS INJURIOUS TO DECIDUOUS SHADE TREES AND THEIR CONTROL

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FARMERS' BULLETIN 1169

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. June, 1921

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 192

HEALTHY APPEARANCE is of the utmost importance in shade trees, and no agency is more potent in marring the appearance of these trees than are insects. A defoliated or otherwise bedraggled shade tree is not only worse than none at all but, when a result of insect injury, it is a menace to the health or life of similar trees in the neighborhood.

Practical ways of controlling most of the injurious shade-tree insects are known. This bulletin discusses the more important insects affecting deciduous shade trees in the eastern two-thirds of the United States with the exception of the gipsy moth and the brown-tail moth and gives the remedies for them. The gipsy moth and brown-tail moth and their control are considered in Farmers' Bulletin 845.

INSECTS INJURIOUS TO DECIDUOUS SHADE TREES AND THEIR CONTROL.

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INTRODUCTORY.

WHY INSECT INJURY IS PREVALENT ON SHADE TREES.

The original home of the trees we plant along our highways and byways is the forest. There, whatever disadvantages they are exposed to, they have acquired a certain degree of resistance to and immunity from insect and probably other normal enemies. Transplanted to our streets, parks, or home grounds they are relieved of the keen competition and other adverse conditions of wild forest life but lose most of the natural advantages of their customary association—sun and shade, moisture and humus—and their proper growth is hampered besides, especially in our cities, by a variety of unfavorable conditions. Hard packed ground, frequently disturbed, often poisoned with oils or gases or charged with electric current, and uncertain or erratic water supply handicap the roots, while constant struggle with thoughtless or reckless man and greedy beast, limited sunshine, and other vicissitudes above ground render their struggle for existence uphill work indeed. Trees so hampered lose much of their native power of resistance and are thereby rendered inviting, easy prey to a variety of disintegrating agencies most prominent among which are insects. This is promptly reflected in their appearance, which is a prime consideration in the usefulness of shade trees. No kind of tree or any part of it is wholly immune from insect pests. Indeed, some parts of trees harbor a large variety of them, and trees are known to be subject to more or less severe attack by hundreds of kinds of insects. In a world thus swarming with these creatures, intent on sharing in practically every one of his enterprises, it is inevitable that man should have to contest every foot of his ground, especially when he adapts nature to his needs, convenience, or comfort.

EXTENT OF INSECT INJURY TO SHADE TREES.

As the growing season advances all shade trees apparently otherwise perfectly healthy will be found on more or less close inspection to show cumulative signs of insect injury, particularly in their foliage. This is inevitable when we consider the great variety of plant-eating insects they harbor. In most cases the injury is too insignificant for treatment. But from this point on the other extreme is not infrequent, when, as a result of abnormal increase of some insect species, the injury may be so severe as to menace the very life of its favorite host tree. Indeed, instances on record are not uncommon in which entire rows of certain trees and most trees of a given kind in communities and regions have been killed by insect pests within a few seasons. Certain trees are more subject to attack and injury and by a greater variety of the seriously injurious insects than others, so that, as a result of a process of selection, such trees are either no longer planted or sparingly, especially where their serious insect enemies are dominant. On the other hand, some of the injurious shade-tree insects, like the white-marked tussock moth, are almost omnivorous, so that practically no deciduous shade tree is immune to their attack and very severe defoliation.

PRIMARY AND SECONDARY INSECT INJURY.

Insects injurious to shade trees may be roughly grouped in accordance with the condition of health of the tree they normally attack. Certain species—and this is especially true of leaf-chewing insects—show a decided preference for perfectly healthy trees. Others—and this is the case with most wood and bark boring insects—can inhabit trees only when the health of these has been previously impaired, whatever the agency responsible for this. These more or less distinctive groups of insects are designated as *primary* and *secondary*, respectively. From the viewpoint of control it is as important to know to which of these an insect found on a tree belongs as it is to know whether it is injurious, beneficial, or indifferent. It is wasted effort to proceed against an insect, even if found injurious, if its presence is conditioned by previous or primary injury or death of the tree. It is the cause of this primary injury that must be discovered and dealt with. On the other hand, there are still a number of insect species that are primary under some conditions and secondary under others, so that they can not be definitely assigned to either group.

GENERAL LIFE OF INSECTS.

Like other living objects, the insects we encounter are the offspring of parents that preceded them—males and females in most cases. Between the time of hatching from the eggs and maturity the growing insects molt, or cast off their skins, three or more times. In some forms, as in the aphids and bugs generally, these immature stages differ little from the adults. In others, as in the beetles, moths, etc., the immature insects, or *larva* stages, as they are called, differ radically in appearance from the adults, and there is, besides the *egg*, another nonfeeding stage or form, known in moths and butterflies as the *chrysalis* and in all of them as the *pupa*. The pupa or chrysalis stage immediately precedes that of the *adult*. The larva of the moth or butterfly is generally known as a *caterpillar*, that of the beetle as a *grub*, that of the fly with two clear wings as a *maggot*, and that of the fly with four clear wings as a *grub*, *slug*, or *false caterpillar*. These forms generally differ sufficiently among themselves for fairly ready assignment to the proper group. Any one of them, except the egg and pupa, may be the injurious form or the one in which the given insect is most advantageously fought; the two—the injuring form and the one treated—not necessarily always being the same. Intelligent control of insect injury, therefore, involves at least a general knowledge of the habits of insects. Among these none is more important than the feeding habit, since this determines largely the control measures to be adopted.

MANNER OF INJURY AND PARTS OF TREE AFFECTED.

In the great majority of cases the mouth of the injurious form of the insect is adapted for feeding either by sucking the sap of the plant (plant-lice or aphids, scale insects, etc.) or by biting off bits of the leaf, bark, or wood (caterpillars, slugs, beetles and their grubs, etc.). The work of the biting insects usually can not be mistaken and, in the case of those feeding on the outside of the host, is often a guide to the remedy, even when the insect is not caught in the act of eating. The sap-sucking insect, on the other hand, must be discovered and its identity or at least the group or family to which it belongs ascertained before the most suitable remedy can be determined.

Injury by either group of insects is manifested in many different ways. Thus, the fine rootlets may be eaten up and the larger roots barked or bored; the trunk and larger branches may be tunneled or their sap sucked; the twigs may be deformed or cut off; the buds and leaves may be deformed; the leaves may have pieces bitten out of them or they may be skeletonized or mined. Some kinds of insects make their home and feed on a large variety of plants; many other kinds, however, utilize only one part of one kind of plant for sustenance.

NATURAL CONTROL OF SHADE-TREE INSECTS.

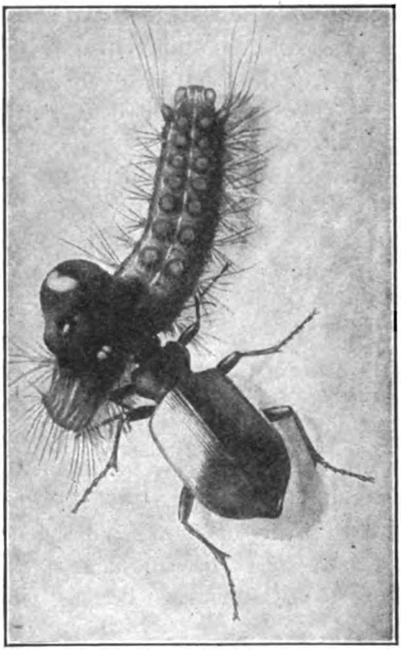

FIG. 1.—Caterpillar of gipsy moth (*Porthetria dispar*) attacked by the Calosoma beetle, *Calosoma sycophanta*. (Burgess and Collins.)

One of the forces which affects insects adversely or otherwise is the weather, this depending upon whether it favors the host tree or the insect. Directly engaged in checking undue multiplication of any given insect are parasitic plants (fungi and bacteria), birds and other vertebrates, spiders, mites, and insects. The insect enemies of insects are usually the most powerful and effective agency in the reduction of a noxious insect. All stages of an insect, from egg to adult, are subject to their attack. These insect enemies operate in two ways, according to their build and habit. Some of them are predacious, in that they seize their prey and eat it either by sucking it dry or by devouring it bodily (fig. 1). Ladybirds are among our best friends among predacious insects. Plant-lice or aphids particularly, but also scale bugs and other soft-bodied insects, are to their liking. Their active young as well as adults feed on these insects. Lace-wing flies, numerous bugs, and certain mites and spiders are among the other recognized predacious insects man has learned to regard with favor for their active feeding on injurious insects. The other group is known as parasitic insects (figs. 2, 3). These are by far the most numerous in variety. By special adaptations some of them are capable of prodigious multiplication and their presence has again and again been found to have saved plants from destruction in situations where man, left to his own devices, was helpless.

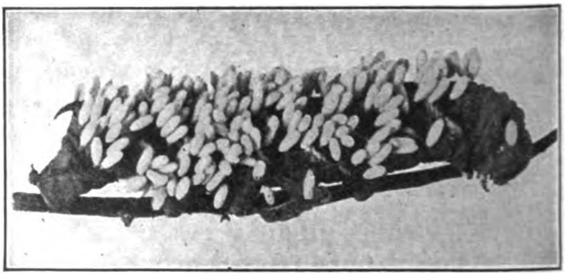

FIG. 2.—Sphinx caterpillar bearing cocoons of small, four-winged wasplike parasite. (Quaintance and Siegler.)

The work of these beneficial insects brings it about that no native insect is ever present in destructive numbers for longer than a year or two, being by the end of that period greatly outnumbered by its enemies and rendered practically harmless. This is particularly noticeable in insects feeding on leaves and on the outside of the plant generally. This is true of all native insects, but not of those that have reached our shores from abroad. In the great majority of cases these were not accompanied by their home enemies, and this accounts for their uninterrupted destructiveness during long periods of time, generally until our native insect parasites and predators develop a taste for them, or until their more effective home enemies have been discovered, imported, and established in their new home, or until these have reached us as accidentally as did their hosts.

PREVENTION OF INFESTATION.

Many shade-tree pests are likely to reach the community by way of the nursery stock. It is imperative, therefore, to insist that young trees be thoroughly cleansed before they are taken from the nursery and certainly before they are planted. Inspection alone, however, can not always be depended upon, for some insect pests are very minute and are apt to hide beyond reach of eye or lens. Fumigation with hydrocyanic-acid gas is at present in general practice in nurseries and is the most reliable means of freeing stock from infestation. If a tree is clean and uninfested at the start, it has stored up vitality which will enable it more successfully to resist subsequent attacks.

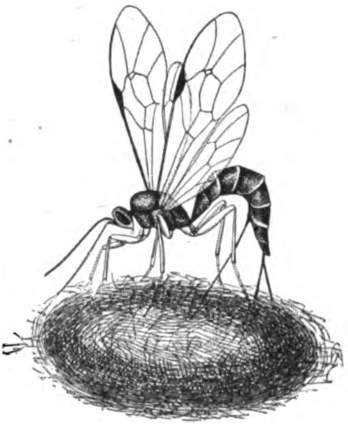

FIG. 3.—Ichneumon fly, Itoplectis, in the act of egg-laying on cocoon of apple-tree tent caterpillar. Enlarged. (Fiske.)

CONTROL, PART OF ROUTINE.

Just as the potato grower in sections of the country invaded by the Colorado potato beetle considers spraying a regular, essential part of successful potato culture, so the municipality must learn to regard regular, periodic inspection of trees for evidence of insect injury, and treatment for it, as necessary to the proper care of its shade trees. The enlightened, efficient tree warden, after a little experience, systematizes this work and dovetails it in with his other duties in such a way as to utilize the labor at his command to best advantage without neglecting other important work. Thus, careful examination of the trees while they are being trimmed, to ascertain the presence or absence of their customary insect enemies and their abundance or scarcity, is good practice and should lead to discovery of many of the insects that are, or in course of the following summer will be, giving trouble. Especially is this true when the warden and his help are familiar with the principal types of shade-tree insects and their more important habits and forms.

TREE "DOCTORS" OR SURGEONS.

The work of the experts on tree pests in the State and Federal Government services is limited to the study of the causative organisms, the discovery and determination of practical methods of controlling them, and the publication of these for general information. The actual work of controlling the pest is thus left to the individual or community, and the limited knowledge of the causes of tree troubles possessed by the general public and the frequent necessity of using rather costly spraying outfits for the control of insects and diseases has created a call for the private enterprise of experts. This requires a knowledge on the part of the expert of the fundamental facts of economic entomology and particularly of the more common injurious insects to be encountered on the trees and the remedies for them as established by the experts in the Government service. His knowledge must, of course, be coupled with integrity, and he must be equipped with adequate spraying and other outfits.

THE CITY OR COMMUNITY ENTOMOLOGIST.

The extension of tree, shrubbery, flower, and vegetable planting in and around cities, both in private yards and along highways, with the attendant insect problems on the one hand and the numerous health and sanitation questions in which household and other insects enter as a vital link in the transmission of disease, point to the advisability for such communities of engaging specialists—entomologists they are called—to look after their individual and collective insect problems. The services of such specialists would more than pay for the outlay in the improved health of the citizens and their surroundings, and especially in the prevention of insect-borne epidemics, like malaria, typhoid fever, etc., as well as defoliation and other destruction of plant life.

STATE AND FEDERAL GOVERNMENT HELP.

Every State and Territory in the Union maintains a staff of competent entomologists glad to assist every citizen in the struggle with insects. The Federal Government does likewise. All inquiries on insects receive ready, intelligent, scientific attention at the hands of these officers, and the information furnished is as complete and accurate as can be given. The labors of these specialists are greatly simplified, however, and the answers can be more direct and prompt if inquiries are accompanied by specimens of the insect, its work, or both, and a description of the extent of the injury and other pertinent information. These officials are glad to receive specimens and information, as it often adds to the knowledge of the distribution of the insects, their habits, etc. A note on the results of treatment is also always welcome.

DIRECTIONS FOR PACKING AND SHIPMENT OF SPECIMENS OF INSECTS AND THEIR WORK.

To receive specific information on insects, insect injury, and remedies promptly—

(1) Address inquiries and specimens to the State entomologist of your State or to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C. This bureau is the only organization in the Federal Government service that is charged with the study of insect problems, so that correspondence on such matters must reach this bureau before it can be given proper attention. Addressing communications to any other office only delays matters.

(2) *The name and address of the writer* should appear plainly on wrappers. *Specimens of live insects and their work*, preferably fresh, should accompany inquiries and should be packed about as follows: (*a*) *Wood and bark borers* are best left in their burrows and the wood or bark containing them cut into convenient sections, tied, and wrapped in two thicknesses of stout paper; (*b*) *leaf-eating insects* (separated by kind, if more than one, to prevent cannibalism), in tight wooden or tin containers or mailing tubes manufactured for the purpose, stocked with their favorite food (holes are unnecessary); (*c*) *underground insects*, in earth; (*d*) *scale insects*, attached to the bark or leaf; (*e*) *leaves and other small specimens* showing insect work inclosed with letters.

When more than one kind is sent, each should be accurately labeled with locality, name of sender, and a number or letter for ready association with corresponding marks in letter or note and with one another. Labels for insertion with alcoholic specimens should be written with soft pencil. Tight, stout containers, properly wrapped, addressed, and tied, prevent escapes, breakage, and loss in transit. Tags must be securely fastened to packages.

(3) *Notes.*—It is very important that specimens be accompanied by information giving as accurately as possible (*a*) name of host tree and part attacked, (*b*) locality, (*c*) date of collection, (*d*) character and extent of injury, (*e*) facilities for disposal of infested timber, and

(*f*) any other information that may help in identifying the insect and determining the proper remedy or control measure suitable to the condition of the correspondent. Notes should readily correspond to labels on specimens, and may be separate or embodied in the letter.

(4) *Shipping specimens.*—Packages not exceeding 4 pounds in weight are most conveniently and cheaply sent by parcels post. Bulky packages may be sent by freight; fragile, by express. They must always be sent prepaid unless otherwise authorized.

THE PRINCIPLES OF SHADE-TREE INSECT CONTROL.

As elsewhere stated, the feeding habit of the insect that is doing the injury is the main factor in determining the kind of remedy to be applied. This is particularly true of the insects that feed in the open, i. e., above ground and on the outside of the plant. In most such instances the principle is very simple: We poison the food of the insect that bites its food before swallowing it and kill the sap-sucking insect with external applications—*contact insecticides* as they are called—which are usually caustic or oily liquids. In a great many cases, however, and especially in insects that live in the interior of the plant tissue, like leaf-miners, gall-makers, borers, and underground workers, be they biting or sucking insects, our method of attacking them must necessarily be different. A vital principle of successful insect control is *wholesale destruction* of them. In emergencies, however, and especially where a single insect is capable of doing serious harm, we do not hesitate to undertake their destruction singly, as in the case of root or stem borers. Again, we often find through a knowledge of their habits that some biting insects, for instance, are more cheaply and effectively fought in some other stage of their lives than in that in which they feed; for example, the destruction of the white-marked tussock moth in the egg stage.

It is evident from what has been stated above that in spraying promptness and thoroughness are vital elements. The earlier in its life the insect is killed the more quickly it is killed and the less harm it will have done; the more completely the foliage is covered with spray the more certain is the early killing of the insects and the more of them will be killed. Likewise, with the sap-sucking insects the more thorough the application the greater the number of the insects that will be hit and killed. *Thoroughness means the complete covering of the insect's food in one case and of all of the insects in the other.*

TREE INJECTIONS: WORTHLESS OR WORSE.

A word on the subject of tree injections is imperative. Perhaps in no other respect are unsophisticated tree owners more imposed upon than in the matter of injection of various cure-all preparations under the bark. Suffice it to say here that *such treatments are entirely without merit* in controlling insects and often are decidedly injurious to the trees treated.

THE STOMACH-POISON SPRAYS.

The standard poisons used at present for killing chewing insects are *arsenate of lead* and *arsenate of lime* (*calcium arsenate*). Both are procurable in the market, usually in seed stores, and come in either paste or powder form. The powder form is preferable for a number of reasons. While these poisons may be prepared at home, it is usually more convenient to buy the prepared article, which only needs to be stirred into water or Bordeaux mixture before being used. The directions for dilution are usually given on the containers. The amounts to be used in small quantities are given in Table I, page 30.

Other poisonous substances are used occasionally, while some, like Paris green, were used extensively, almost exclusively, until superseded by arsenate of lead and arsenate of lime. The lower cost and greater fineness and adhesiveness of the last two make their use most general now.

Being violent poisons, these substances should be stored and handled with due caution, especially as regards live stock and children.

THE CONTACT SPRAYS.

As elsewhere stated, contact sprays are used to kill sap-sucking insects, like scale bugs, aphids or plant-lice, etc. Death is produced by the coating and clogging of their breathing pores, by affecting the nervous system, or by caustic action on the tissue of the insect, or by combinations of these. Lime and sulphur compounds, soaps, petroleum oils, and tobacco extracts are the active agents in these preparations.

Lime-sulphur, *miscible oil*, *kerosene emulsion*, and *40 per cent nicotine sulphate* are contact sprays. With the exception of kerosene emulsion, which must be prepared at home, all of them are procurable commercially, where each is sold under a variety of proprietary names. All that they require to be made ready for application is to be stirred into water, with the addition of a little soap in the case of the nicotine. Directions for dilution are usually printed on containers and should be followed carefully. For small quantities see Table I, page 30

LIME-SULPHUR.

Lime-sulphur, as an insecticide, is used almost exclusively against the so-called armored scale insects, like the San Jose and oyster-shell scales, and principally as a dormant or early spring spray. It is the cheapest of the scale-killing sprays, but unfortunately it *discolors paints* and, as most shade trees are located in greater or less proximity to buildings, its use is limited to trees not so located and to nursery stock. Wherever practicable to apply it with a paint brush, its cheapness may offset the labor cost. The concentrated preparation as bought should have a density of about 33° on the Baumé scale. At this strength it should be used at the rate of 1 pint in each gallon of spray. See Table I, page 30.

MISCIBLE OR WATER-SOLUBLE OILS.

In shade-tree work the miscible oils are used especially against scale insects and are the only ready-prepared substances available on the market that will effectively control all kinds of scales as does kerosene emulsion. These preparations come under a variety of proprietary names and vary somewhat in strength, so that directions for dilution as given on the containers must be followed carefully. The miscible oils are primarily winter sprays, being used at this season on account of the absence of foliage, which they are apt to injure. Since they are used principally in the control of scale insects, their application while the plants are dormant is most satisfactory anyway, because, in the absence of foliage, the insects are more easily reached, the covering with spray can be more complete, less spray solution is required, and the spray can be more safely applied at greater strengths, thereby killing the insects with greater certainty.

CREOSOTE OIL.

Creosote has been found very useful in daubing tussock-moth eggs. It is apt to thicken in cold weather and is then thinned with turpentine.

KEROSENE.

Kerosene is also useful on a mop at the end of a pole for daubing tent caterpillars and webworms or tussock-moth eggs, or, with proper caution, the kerosene on the mop may be lit and used as a torch to burn out the caterpillars in the tent or web.

KEROSENE EMULSION.

Kerosene emulsion is a standard contact spray, composed of kerosene, soap, and water in certain proportions. By varying the proportion of water, this spray can be used both summer and winter against scales and soft-bodied insects. The emulsion, as the concentrated mixture is called, is likely to deteriorate in storage, by breaking up into the kerosene and soap solution from which it was made. For "homemade" emulsion the best procedure is to prepare a stock mixture first and then dilute it as needed. This stock mixture may be made up in quantities, and if properly prepared it should keep for some time.

Kerosene-emulsion stock is most conveniently prepared as follows:

Kerosene	gallons	2
Fish oil or laundry soap (or soft soap, 1 quart)	pound	½
Water	gallon	1

Put the water and soap into a wash boiler or similar vessel and heat until the water boils and the soap is dissolved; remove from the fire, add the kerosene, and stir vigorously for about five minutes until the mixture is creamlike in consistency. A convenient way to make the mixture thorough is to pour the soap solution and kerosene into the tank of the spray pump and, through the nozzle, to pump the mixture back into the tank for several minutes.

For spraying, this stock mixture is diluted with water, which is best done at the time and in quantities needed. For summer spraying, on trees in foliage, add 5⅔ gallons of water to each gallon of the stock preparation. For winter use, on dormant trees, 1⅔ to 2⅓ gallons of water are added to each gallon of the stock. For smaller quantities see Table I, p. 30.

POISONED CONTACT SPRAY.

In this preparation the contact solution is used as a conveyer of the poison in situations where the ordinary water solution of the poison could not penetrate. It was specially devised to reach and kill borers while they are still feeding in the bark, and is prepared as follows:

In each gallon of water used for diluting the contact preparation, be it kerosene emulsion or water-soluble oil, dissolve 1 ounce of sodium arsenite, before making the mixture. Sodium arsenite is readily soluble in water and is procurable in drug stores. The crude or commercial product, which is cheaper, will answer the purpose. This preparation is injurious to foliage, which should be borne in mind when applications are made with it.

NICOTINE SULPHATE.

Nicotine sulphate is a specific remedy for aphids or plant-lice, but other soft-bodied insects can also be killed with it. It is a liquid extract of tobacco procurable in a variety of stores under a variety of trade names and varying in strength. The preparation is merely diluted with water before use, and the proportions are usually given on containers. The 40 per cent nicotine sulphate is the most commonly available; although when properly diluted, any strength of the stock preparation will answer. It is necessary to add 1 ounce of soap to each gallon of the spray to insure its spread and adhesion.

CARBON DISULPHID.

Carbon disulphid is a heavy, ill-smelling liquid, procurable in drug, seed, and other stores. It evaporates readily at the normal temperature, and as its vapor is heavier than air, it sinks. *It is highly inflammable and has a poisoning effect when inhaled freely, so that caution in handling it is necessary.*

In shade-tree work it is used for killing borers, being injected by means of an oil or other squirt can or dropper into the borer opening, the hole being promptly plugged with putty, grafting wax, or similar substance. In similar manner it may be used against carpenter ants.

FISH-OIL OR LAUNDRY SOAP.

Fish-oil soap, sometimes known as "whale-oil" soap, is procurable commercially and is an effective insecticide for such insects as aphids, scale bugs, and other sap-sucking kinds. Common laundry soap may also be used for this purpose. For summer spraying, dissolve 1 pound of the soap in 3 to 4 gallons of water. For winter spraying on scale insects, dissolve 2 pounds of the soap in each gallon of water over the fire and apply the spray before the solution is cold and congeals, which it is apt to do in this concentration.

Soap has other uses in the treatment of trees. Thus, with nicotine solutions it is used as a "spreader" or adhesive (see p. 13). In connection with injections of carbon disulphid it may be used to plug the treated holes to prevent loss of the fumes.

TREATMENT OF TREE WOUNDS.[1]

Tree wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, horses, vehicles, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. When a limb is cut off, the edge of the bark and the cambium should be coated with shellac as soon as the surface is sufficiently dry to permit it to stick, otherwise the value of the shellac is practically lost. The wound is then ready to be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined in a mixture containing about one-third creosote and two-thirds coal tar. One coat of the mixed materials may be sufficient, but if not, a heavy application of the coal tar should be used, and the surface recoated whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, while not as satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces.

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[1] Adapted from Farmers' Bulletin 908.

FILLING TREE CAVITIES.[2]

Decayed scars and cavities in the trunk or limbs are frequently infested with wood-boring larvæ or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees, but they afford an excellent winter harbor for certain injurious insects. As noted elsewhere (p. 16), cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities may be filled with cement and the condition of the trees materially improved.

The first operation is to remove all of the decayed wood, and this can be done by means of a gouge, chisel, mallet, and knife. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. As soon as the cambium has been cut to a proper distance it should be covered with a coat of shellac. After the cavity has been thoroughly cleaned out it should be treated with creosote and coal tar, as described under the preceding heading, and it is then ready to receive the permanent filling.[3]

PRUNING AS RELATED TO INSECT INJURY.[4]

Certain twigs and branches, when heavily infested with or injured by insects, frequently can be removed to best advantage in the course of pruning operations. Also, in the work of pruning, thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In case of severe insect injury, large trees may sometimes be severely cut back or "dehorned" to advantage. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects or punctured by the periodical cicada, or tree-hoppers, etc., usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later.

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[2] Adapted from Farmers' Bulletin 908.

[3] For full information on this subject, see "Tree Surgery" by J. F. Collins, Farmers' Bulletin 1178, U. S. Department of Agriculture.

[4] Adapted from Farmers' Bulletin 908. The general subject of pruning shade trees is discussed in Bulletin 816, U. S. Department of Agriculture, and in Farmers' Bulletin 1178.

All dead and dying trees and limbs should be promptly removed and burned, as they attract wood-boring insects which may become abundant and attack and injure healthy trees. When limbs of trees are being removed they should be sawed as closely to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and will afford a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 to 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the remaining stub close to the tree trunk and in line with its woody surface, taking care, however. to support the stub until completely severed.

STIMULATION OF GROWTH BY FERTILIZATION, ETC.[5]

Unthrifty trees are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, often will result in marked improvement.

MISCELLANEOUS INSECT-KILLING IMPLEMENTS.

Elsewhere in this bulletin the point was made that wholesale destruction is an essential consideration in the profitable control of insects wherever this is practicable. In the case of large trees the insects are generally beyond unaided reach and usually too numerous for profitable individual hand picking. Hence, mechanical devices of some sort, ranging from the ordinary paint or whitewash brush or pole and mop to the most complicated power drawn and propelled spraying outfit, are generally employed in this work. Local conditions and the insect involved largely determine the sort of instrument to be used in any given case.

THE PAINT OR WHITEWASH BRUSH.

In the absence of spraying machinery or for other reasons a single shade tree or small number of them requiring treatment of trunk and larger branches, as for scale insects, may often be saved from serious injury or utter ruin by the application of an insecticide with a paint or whitewash brush. With proper protection of the painter's hands and face even lime sulphur, which is somewhat caustic to the bare skin, may be used to advantage, for it is considerably cheaper than other preparations, and a brush application will insure against possible injury to paints on buildings near by. The brush has also the advantage of being perhaps least costly and it is certainly the simplest tool for the purpose.

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[5] Adapted from Farmers' Bulletin 908.

THE MOP.

The mop may consist of nothing more than a bundle of rags tied to the end of a pole. Saturated with kerosene or creosote it may be used for daubing tent caterpillars and webworms or tussock-moth eggs, which are thus killed most rapidly. If lighted, the kerosene-soaked mop may be converted into a torch and webs burned out, provided it is handled deftly so that the live wood is not burned.

TREE BANDING.

INDISCRIMINATE USE OF BANDS FUTILE.

The habit of some insects, at certain definite stages of their lives, of traveling in mass along the tree trunk has suggested the use of bands as barriers or traps. Against certain wingless female moths, also, like cankerworm moths, this method of control may be made operative. Various materials are serviceable for this purpose, gunny-sacking, cotton batting, and fine-mesh wire screen being employed and, in recent years, certain sticky substances have come into quite general use.

It is evident that the usefulness of such bands is restricted to tree-infesting insects having the habits above mentioned. Unfortunately many people have gained the erroneous impression, especially since the use of sticky bands has come into vogue, that these bands are a panacea for all tree troubles caused by insects. The result has naturally been the indiscriminate use of bands, often with the disastrous consequences that might have been expected under the circumstances. There is no royal road to insect control. The bands, even where the insect's habit allows of their usefulness, will be effective only when watched constantly so that clogging, bridging, drying up, and other contingencies may be guarded against. Banding should be resorted to only after consultation with an entomologist. Wherever applicable, the following bands are recommended:

COTTON BATTING.

Take a band of cotton batting 6 to 8 inches wide and a little longer than sufficient to encircle the trunk of the tree at a convenient height, wrap it around the tree, and tie the bottom edge of it securely, turning the upper edge down over the string so as to form a flange of loose cotton all around the tree. (Fig. 4.) It should be borne in mind that this barrier will remain effective only so long as the cotton remains fluffy, and even then, especially if the insects are very numerous, frequent examination of the band is necessary if it is to be kept in proper working order.

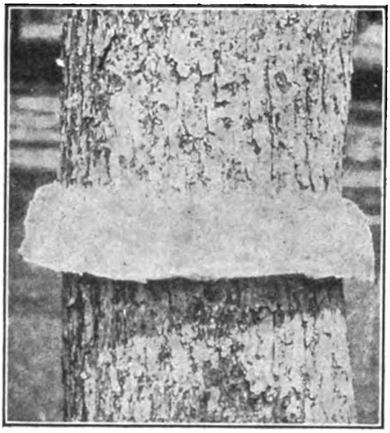

FIG. 4.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

WIRE SCREEN.

Wire screen may be used to trap nonflying moths like those of the cankerworms and tussock moth to prevent them from crawling up the tree. Ordinary 12-inch 12-mesh fly screen is cut on a bias into pieces long enough at the top to overlap an inch or so after encircling the tree trunk at the desired height and about 6 inches longer at the bottom. Fasten the upper edge snugly around the tree with small carpet tacks and let the ends meet on a bias, so that the looser edge of the band stands away from the trunk about an inch all around and admits the ascending insects freely. Where a number of uniform sized trees are to be banded at the same time, the wire strip may be cut up as suggested on the accompanying outline (fig. 5).

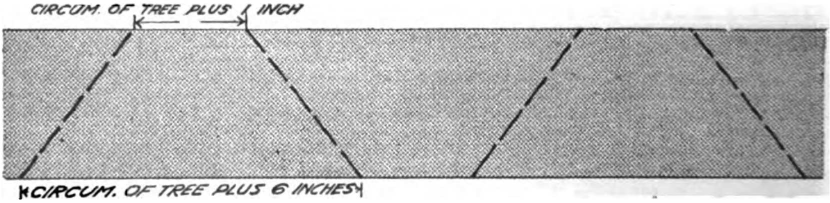

FIG. 5.—Diagram of strip of wire screen with broken lines showing how to cut it for insect guards.

These bands must be examined daily and moths collected under them crushed, as the tiny larvæ hatching from eggs they may lay will readily penetrate the screen. Because of this necessity, the use of wire bands is practicable only in limited instances.

STICKY BANDS.

Applied directly to the bark of the tree sticky bands may be injurious. The injury may be prevented, however, by applying the preparation on a strip of heavy paper. As such paper can not be made to fit snugly, cheap cotton batting may be used underneath it.

The process then is as follows: Cut a strip of cotton about 2 inches wide and wrap it around the tree trunk so as to fill all the crevices of the bark. Over the cotton place a strip of 1-ply building tar paper about 5 inches wide, draw it tightly, and tack it securely where it overlaps. The adhesive is then spread out on the paper. (Fig. 6.)

The sticky preparation is apt to become dry or covered with dust and insects and, in consequence, fail to function, so that it should be either renewed from time to time or it may be renovated by combing it so as to remove obstructions and bring the fresh material to the surface.

Sheets of sticky fly paper may be used for tree banding, in emergencies. They are best placed over bands of cotton batting, as described above, and fastened to the trunk by means of heavy twine tied tightly around the upper and lower edges.

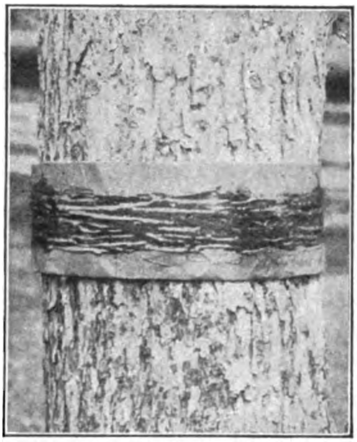

Fig. 6.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

STICKY PREPARATIONS FOR BANDING.[5]

The market offers proprietary preparations for banding which are frequently preferred because ready for use. Where materials, facilities, and time are available, however, these preparations may be made at home. Homemade preparations offer advantages in that adulterant or harmful substances are sure to be excluded, the cost will be less, and substances may be used up that might otherwise go to waste. Following are some of the substances and mixture that may be employed for this purpose:

ROSIN-CASTOR OIL MIXTURE.[6]

Place 5 pounds of rosin and 3 pints of castor oil in a pot and heat slowly until the rosin is melted. Add more oil if the resultant is too thick.

AXLE GREASE, FISH OIL, AND ROSIN.[6]

These substances are used in Europe for the preparation of a tree-banding mixture which is reported effective. The mixture is made as follows:

Axle grease	pound	1
Fish oil	pint	1
Powdered rosin	pounds	2

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[5] See also Department Bulletin 899, "Gipsy Moth Tree-Banding Material: How to Make, Use, and Apply It," which may be obtained from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

The rosin-castor oil mixture and the mixture of axle grease, fish oil, and rosin have been tested by the Bureau of Entomology in New England for banding purposes but are unsatisfactory in that region.

Heat the axle grease in a cooking vessel of at least a gallon capacity until all the water in it is evaporated. Without removing this from the fire, stir in the fish oil, followed by the powdered rosin, a little at a time. When the latter is dissolved, remove from the fire, and the mixture is ready for use next day.

PRINTER'S INK.

Refuse printer's ink, sold as "tree ink," may be used for tree-banding purposes, but it should be mixed with a heavy oil to prevent it from drying too rapidly.

SPRAYING OUTFITS FOR SMALL OPERATIONS.[7]

HAND ATOMIZERS.

For spraying a few plants or very small trees, hand atomizers (fig. 7) may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart.

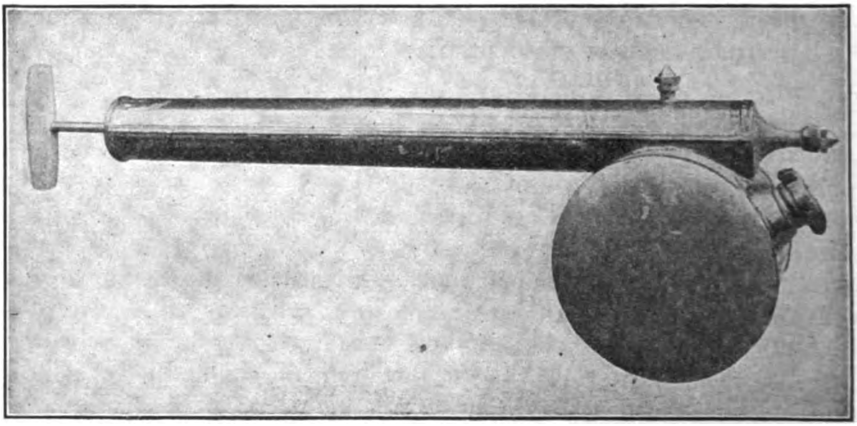

FIG. 7.—Hand atomizer, useful for spraying small plants or low-growing trees. (Quaintance and Siegler.)

SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 8) are now most frequently used in small-scale spraying, and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4 gallons. They are carried by means of a shoulder strap. In the better types agitation is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank, and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. The tank is usually emptied by three to four pumpings of a dozen strokes each.

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[7] Adapted from Farmers' Bulletin 908.

BARREL PUMPS.

The barrel hand-pump outfit (fig. 9) has a capacity of about 50 gallons, and may be used to advantage on a limited number of trees. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and the whole outfit placed on skids or on a wagon. On hilly land it is preferable to have the barrel in a horizontal position.

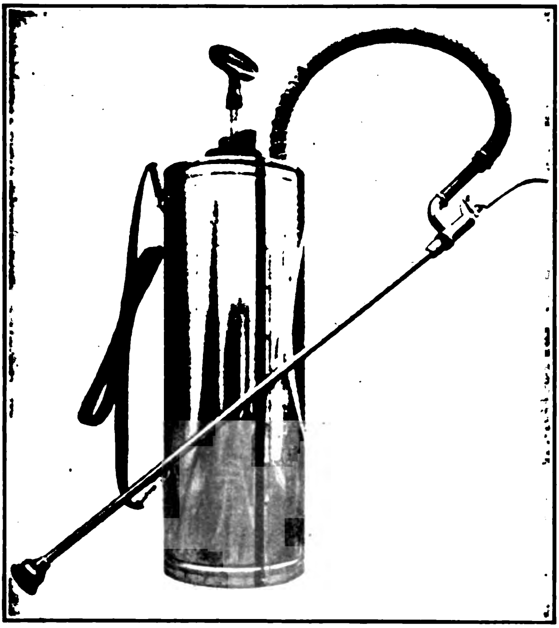

FIG. 8.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying. (Quaintance and Siegler.)

DOUBLE-ACTION HAND PUMPS.

The double-action hand pumps (fig. 10) usually are employed in connection with spray tanks of greater capacity than a barrel, as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform, and placed on top of the tank or on a platform at the hind end of the wagon. A suction hose extends into the spray tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer.

A common defect is lack of adequate facilites for agitation, although tanks are available in which this deficiency is corrected to some extent.

SPRAYING OUTFITS FOR LARGE OPERATIONS.[8]

Spraying outfits in larger towns and cities are generally best operated by gasoline engines. In an emergency even the fire engines may be utilized for this purpose in some communities.

GASOLINE-POWER SPRAYERS.

Spray pumps, operated by gasoline engines, are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

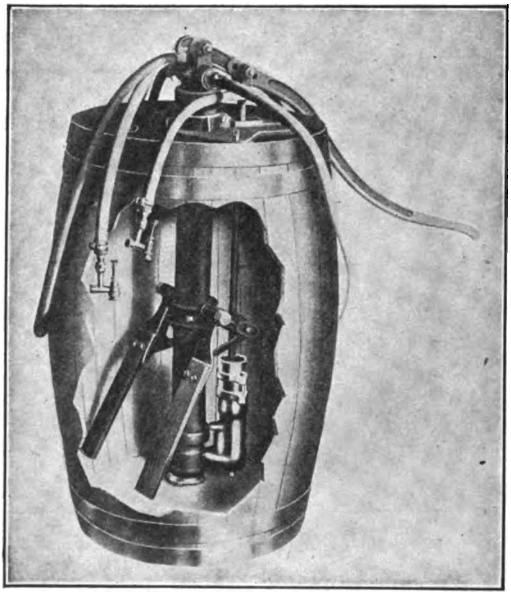

FIG. 9.—Barrel pump, suitable for spraying a few medium-sized trees. (Quaintance and Siegler.)

The smallest power sprayers are nothing more than ordinary barrel pumps equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and at a higher pressure than will the pumps operated by hand. With the small power outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (see title-page) are made with pumps of from two to four cylinders, having a capacity of 5 to 50 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are operated by gasoline engines of from 2 to 12 horsepower. For the four-cylinder pumps of large capacity, auto-type 4-cylinder engines of 10 to 12 horsepower are sometimes used.

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[8] Adapted from Farmers' Bulletin 908.

In the extensive spraying operations in New England for the gipsy and brown-tail moths motor-truck sprayers[9] (fig. 11) have been used to great advantage.

The makes of spray machines now on the market vary a good deal in durability and efficiency. The tree warden, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements.

SPRAYING ACCESSORIES.[10]

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save time or aid the tree warden in doing more thorough work should be provided. The equipment need not necessarily be elaborate or expensive, but should be sufficiently complete and modern so that there will be no handicap when the time to spray is at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy loss.

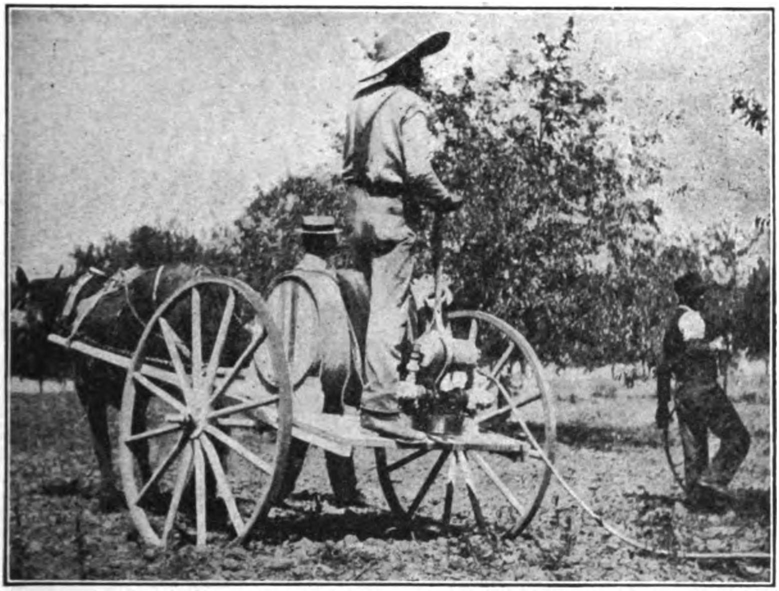

FIG. 10.—Double-action hand pump for spraying home grounds or in the small community. (Quaintance and Siegler.)

SPRAY NOZZLES.

Manufacturers of spraying machinery and accessories have placed on the market a large number of nozzles to which they have given various trade names. Although these nozzles differ somewhat in size and style, the principle of construction is not distinctive for each.

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[9] Department Bulletin 480, "Solid-Stream Spraying Against the Gipsy Moth and Brown-Tail Moth in New England," contains full information on the subject and may be purchased from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

[10] Adapted from Farmers' Bulletin 908.

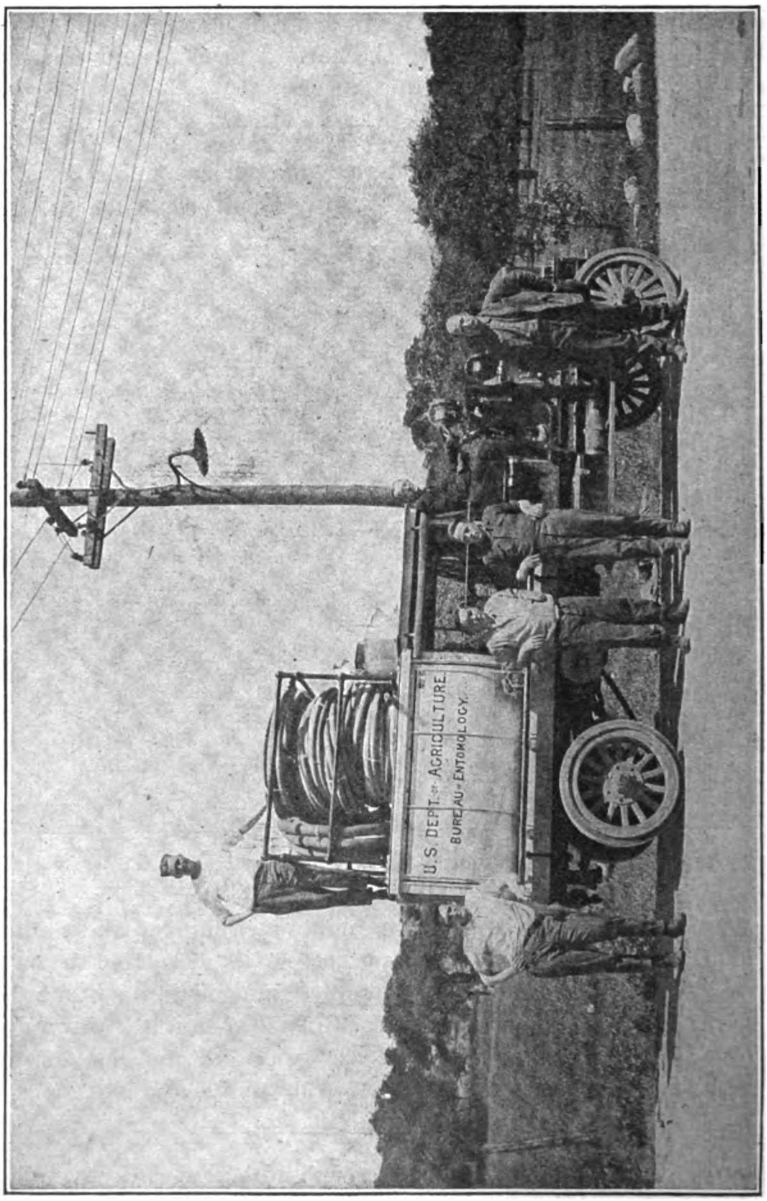

FIG. 11.—Motor-truck sprayer of the Bureau of Entomology with crew and equipment. (Worthley.)

The nozzle type most suitable for shade-tree spraying is that known as the whirlpool disk type (fig. 12). It is as well adapted for use with small spraying outfits as with larger ones. These nozzles are usually provided with three interchangeable disks or plates, each having a different sized opening to give a fine, medium, or coarse spray. The spray material passes through a tangential opening into the eddy chamber, where it obtains its whirling motion and escapes through the opening in the disk. The disk nozzles are relatively small and compact and, owing to the absence of any appendages, do not catch in the branches of trees as happens with other designs. The coarse spray disks deliver a fairly large quantity of spray material, and can not be used satisfactorily with pumps of small pressure capacity. With the smaller spraying outfits the disks having small apertures should be used.

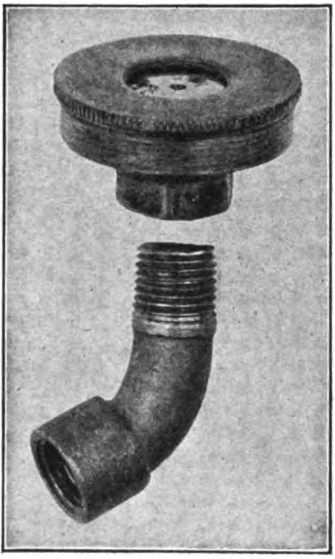

FIG. 12.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook. (Quaintance and Siegler.)

NOZZLE Y.

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a Y.

SPRAY RODS.

Spray or extension rods (fig. 13) are employed in order to reach the upper and inner parts of the trees. These generally consist of an aluminum, brass, or iron rod contained within a bamboo pole and are usually made in lengths of from 6 to 14 feet. Some fruit growers use an ordinary gas pipe, but the lighter weight spray rods are much more desirable.

ANGLE SHUT-OFF.

An angle shut-off, connecting the spray hose with the base of the spray rod, is a convenient device for cutting off the spray material whenever desired, as in passing from one tree to another. The angle construction permits the hose to hang in its natural position, and thereby saves the hose from wearing at the coupling. Without an angle shut-off, spray material is frequently wasted because of the inconvenience of closing the stopcock.

THE WORTHLEY NOZZLE, FOR SOLID-STREAM SPRAYING.

In the spraying of shade trees, which, when full grown, are usually quite tall and large generally, the time and labor previously required in climbing in order to reach the top have constituted the heaviest item of expense in insect control. The introduction of solid-stream spraying has largely eliminated this expense, and the Worthley nozzle (fig. 14) is a material help in the same direction. It is in effect a combination of extension rod and nozzle. With this nozzle the tops of trees 85 feet high and higher can be reached from the ground quite effectively. To break the force of the stream, so that small trees and the lower foliage of large trees may be properly sprayed, a strip of brass, slightly curved, about 10 inches long and 1¼ inches wide, known as a spreader (fig. 14, B), is attached to a brass ferrule about a foot in length, so that it can be moved up and down the tube of the nozzle. When this brass strip is slid beyond the tip the solution forcibly coming in contact with it is broken up into a fan-shaped stream, thus giving a good mist spray.

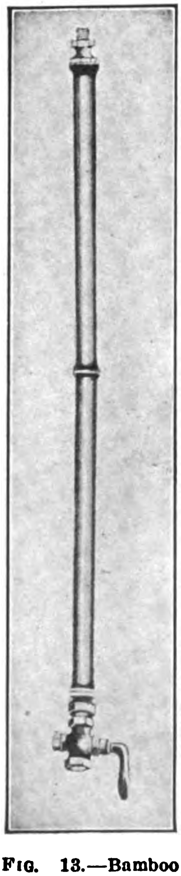
FIG. 13.—Bamboo spray rod. (Quaintance and Siegler.)

SPRAY HOSE.

Only the best grade of high-pressure hose, usually about three-eighths to one-half inch inside diameter, should be used for spraying operations. The length of the hose for spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In large tree spraying, from 50 to 150 feet, with an average of about 100 feet of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. Special conditions may require greater lengths of hose.

HOSE COUPLINGS AND CLAMPS.

It is poor economy to use light-weight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

TANK FILLERS.

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the community is provided with a convenient water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern, pond, etc.

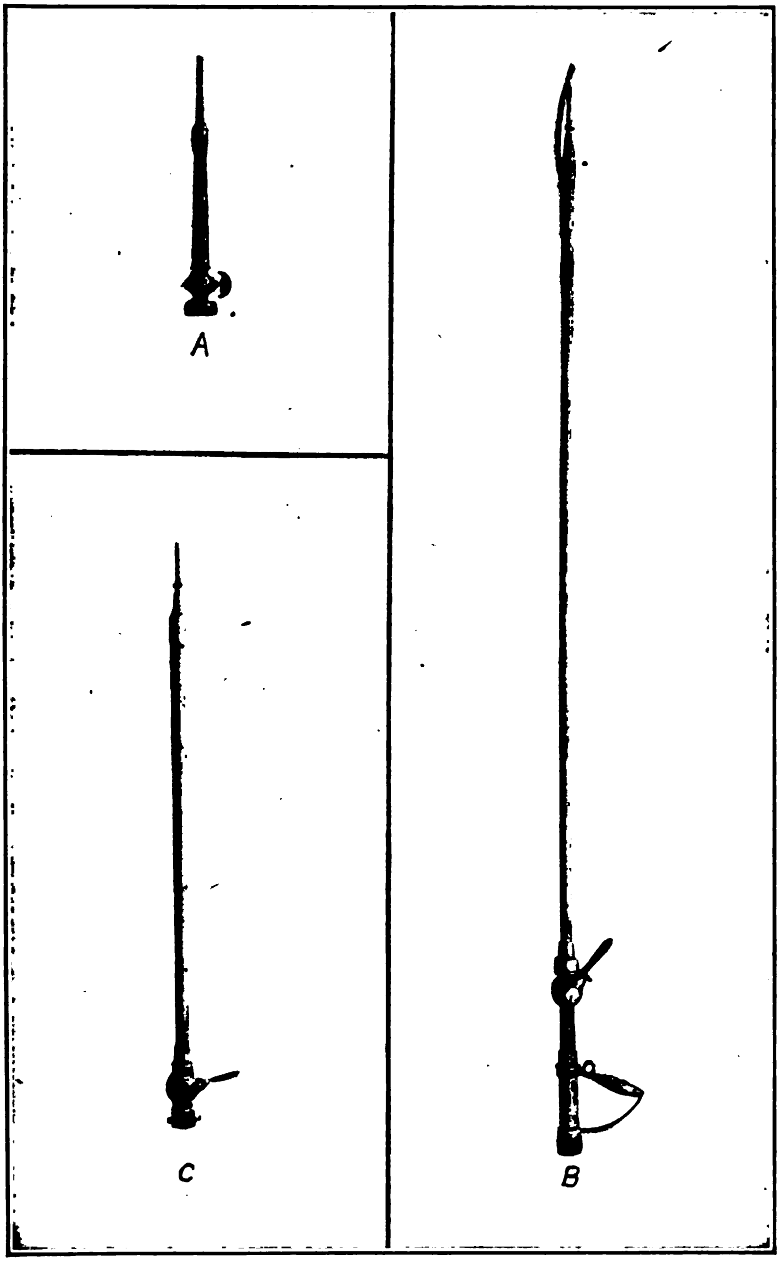

FIG. 14.—Nozzles for solid-stream sprayer. A, Old type nozzle; B, latest type, known as the Worthley nozzle, with spreader; C, smaller size, same type as B. (Worthley.)

Rotary pumps (fig. 15) connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in districts where the water is drawn from the irrigation ditches.

PRESSURE REGULATOR.

This is a useful attachment for the regulation of the pressure. By its proper adjustment a uniform spray is obtained at the pressure desired.

MISCELLANEOUS SPRAYING SUPPLIES.

The following accessories should be provided:

Scales.—A good pair of scales should be used for weighing out the spray materials. Guess-work is poor economy.

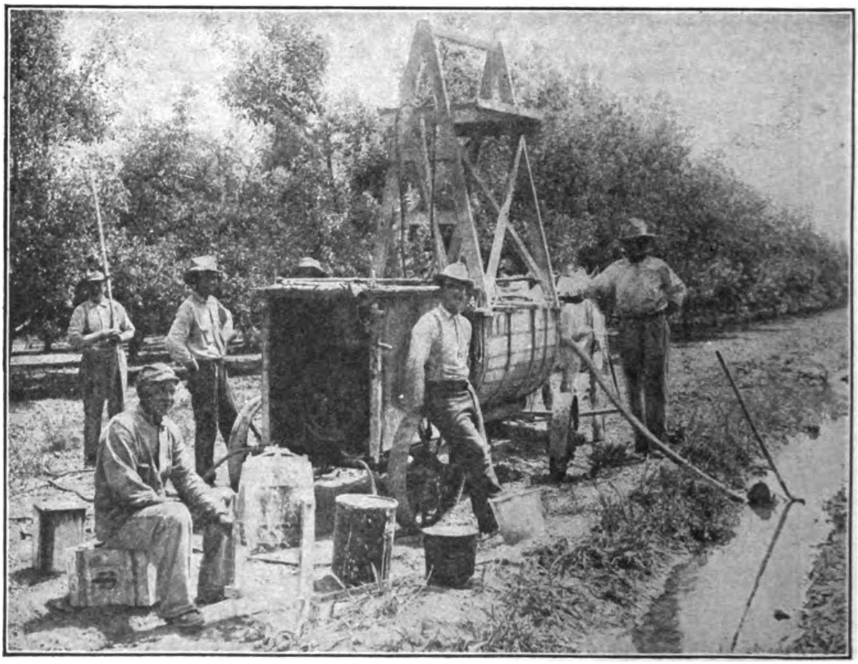

FIG. 15.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary pump tank filler. (Quaintance and Siegler.)

Galvanized buckets.—These are useful for measuring liquid spray materials, especially when gallons and smaller quantities are marked on them by means of graduating dents.

Strainer.—Before admitting spray material into the spray tank, it should first pass through a screen (fig. 16) to remove all of the coarse particles. The opening in the spray tank for filling purposes is usually provided with a removable brass screen.

Extra parts.—Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

Tools.—Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, however, such as wrenches, screw drivers, hammers, etc., should be carried in the tool box in case of need.

Help.—In solid-stream power spraying at least 5 men are required: One mechanic and driver (or chauffeur if the outfit is mounted on a power truck), three men at the hose, and one at the nozzle. If more than 150 feet of hose are used, more men will be needed.

It is perhaps not out of place to state here that, in view of the fact that spraying is practically futile unless it is intelligently done, it is not only desirable to have the help in this work intelligent and measurably well informed, but also to have the rewards of their labor sufficiently attractive to hold them to a certain degree of permanence, thereby insuring effectiveness and efficiency. In the long run such a policy will prove the cheapest and most satisfactory.

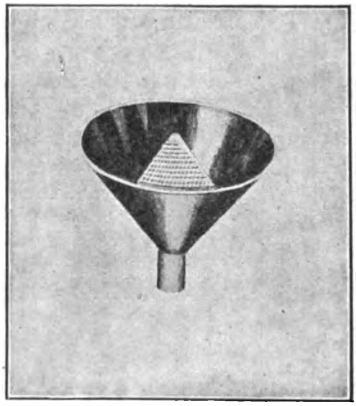

FIG. 16.—Strainer for use in removing sediment in sprays when these are being poured into the spray tank. (Quaintance and Siegler.)

SPRAY DILUTION TABLE FOR READY REFERENCE.[11]

Table I shows the amount of spray material required for a number of different quantities of spray. The rate at which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the amount of spray material required. Thus, if 150 gallons of arsenate of lead, paste, at the rate of 2 pounds to 50 gallons, is to be used, it will be noted in the table that 6 pounds is required. Again, if 100 gallons of kerosene emulsion, 10 per cent strength, is wanted and the stock solution contains 66 per cent of kerosene, it will be found by referring to the table that 15 gallons of the stock emulsion should be used.

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[11] Adapted from Farmers' Bulletin 908.

TABLE I.—*Spray dilution table for ready reference. (A) For trees in foliage; (B) for dormant trees.*

	Total gallons of diluted spray material.									
	200	150	100	50	25	20	15	10	5	1
(A) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR TREES IN FOLIAGE.										
Stomach poisons.										
Arsenate of lead, paste, 2 lbs. to 50 gals	8 lbs.	6 lbs.	4 lbs.	2 lbs.	1 lb.	12.8 oz.	9.6 oz.	6.4 oz.	3.2 oz.	0.64 oz. or 1 teaspoonful.
Arsenate of lead, powder, 1 lb. to 50 gals	4 lbs.	3 lbs.	2 lbs.	1 lb.	8 oz.	6.4 oz.	4.8 oz.	3.2 oz.	1.6 oz.	0.32 oz. or 3 teaspoonfuls.
Arsenate of lime, paste, 2 lbs. to 50 gals	8 lbs.	6 lbs.	4 lbs.	2 lbs.	1 lb.	12.8 oz.	9.6 oz.	6.4 oz.	3.2 oz.	0.64 oz. or 1.5 teaspoonfuls.
Arsenate of lime, powder, ¾ lb. to 50 gals	3 lbs.	2.25 lbs.	1.5 lbs.	12 oz.	6 oz.	4.8 oz.	3.6 oz.	2.4 oz.	1.2 oz.	0.24 oz. or 2 teaspoonfuls.
Paris green, 6 oz. to 50 gals	1.5 lbs.	1.12 lbs.	12 oz.	6 oz.	3 oz.	2.4 oz.	1.8 oz.	1.2 oz.	0.6 oz.	0.12 oz. or 0.5 teaspoonful.
Contact sprays.										
Nicotine sulphate (40%), 1 to 800=½ pt. to 50 gals.	1 qt.	1.5 pts.	1 pt.	8 fl. oz.	4 fl. oz.	3.2 fl. oz.	2.4 fl. oz.	1.6 fl. oz.	0.8 fl. oz.	1 teaspoonful.
Nicotine sulphate (40%), 1 to 1,066=⅜ pt. to 50 gals.	1.5 pts.	1.12 pts.	12 fl. oz.	6 fl. oz.	3 fl. oz.	2.4 fl. oz.	1.8 fl. oz.	1.2 fl. oz.	0.6 fl. oz.	0.75 teaspoonful.
Kerosene emulsion (66%), 10% strength	30 gals.	22.5 gals.	15 gals.	7.5 gals.	3.75 gals.	3 gals.	2.25 gals.	1.5 gals.	3 qts.	1.2 pints.
Fish-oil soap, 1 lb. to 4 gals				12.5 lbs.	6.25 lbs.	5 lbs.	3.75 lbs.	2.5 lbs.	1.25 lbs.	4 oz.
(B) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR DORMANT TREES.										
Contact sprays.										
Lime-sulphur concentrate (33° B.), 1 gal. to 8 gals.	25 gals.	18.75 gals.	12.5 gals.	6.25 gals.	3.12 gals.	2.5 gals.	1.87 gals.	1.25 gals.	2.5 qts.	1 pint.
Lime-sulphur concentrate (33° B.), 1 gal. to 9.5 gals.	21 gals.	15.75 gals.	10.5 gals.	5.25 gals.	2.62 gals.	2.1 gals.	1.57 gals.	1.05 gals.	2 qts.	0.84 pint.
Kerosene emulsion (66%), 25% strength	76 gals.	57 gals.	38 gals.	19 gals.	9.5 gals.	7.6 gals.	5.7 gals.	3.8 gals.	1.9 gals.	3 pints.
Kerosene emulsion (66%), 20% strength	60 gals.	45 gals.	30 gals.	15 gals.	7.5 gals.	6 gals.	4.5 gals.	3 gals.	1.5 gals.	2.4 pints.
Fish-oil soap, 2 lbs. to 1 gal	400 lbs.	300 lbs.	200 lbs.	100 lbs.	50 lbs.	40 lbs.	30 lbs.	20 lbs.	10 lbs.	2 lbs.

Abbreviations: oz.=ounce; lb.=pound; fl. oz.=fluid ounce; pt.=pint; qt.=quart; gal.=gallon. Weights: 16 ounces=1 pound. Measures: 7 teaspoonfuls=1 fluid ounce; 16 fluid ounces=1 pint; 32 fluid ounces=1 quart; 4 quarts=1 gallon.

LEAF-CHEWING INSECTS.

GENERAL.

The life of the deciduous tree attacked by leaf-chewing insects is directly endangered by them only when they keep the tree in a state of complete defoliation for several years in succession. Fortunately this condition can apparently be brought about only by recent insect pest immigrants before our native predacious and parasitic insects develop an appetite for them. This was true not so many years ago of the elm leaf-beetle, for instance, which is only an occasional and local pest at present owing to the effective work of predacious bugs that feed on its eggs. Nevertheless, aside from disfiguring the tree for the season, defoliation tends to reduce its vitality more or less, and this often leads to its attack by other insects, principally bark and wood borers, which are much harder to combat and the injury of which not infrequently results in fatalities among trees. For these reasons, as well as the fact that it is the most easily done, it is advisable, wherever practical considerations permit, to check defoliation as soon as observed. As not every hole in the foliage necessarily indicates the presence of a defoliator this point is best first definitely ascertained before the labor and expense of spraying are undertaken. Municipalities, however, should always be prepared for such emergencies by having on hand the necessary machinery and supplies for a prompt, thorough, and quick job.

BAGWORM.[13]

Recognition of work.—Although arborvitæ and other evergreens are the favorite food of the bagworm, broad-leafed trees and shrubs are not infrequently discovered to have their foliage eaten and bearing rough looking, more or less spindle shaped bags up to 2 inches long (fig. 17). On closer examination a head and six legs are found protruding from the opening at the upper end of the bag. Badly defoliated trees during the dormant season are bespangled with such bags, although at that time most of these contain eggs instead of caterpillars.

Habits and seasonal history.—The bagworms attain full growth in the District of Columbia toward the end of August, whereupon they transform to pupæ. About three weeks later these change into adult moths, of which the females are wingless and do not leave the bag. The males alone emerge from the bags and fly in search of females, with which they mate. Immediately thereafter the female begins laying her eggs, with which she nearly fills her old chrysalis skin in the bag, wriggles out of it, and dies. The eggs thus laid pass the winter in the bag and late the following spring hatch into caterpillars, which make their way to the nearest leaf and immediately begin to feed and construct bags for themselves. The bags are made from bits of the foliage on which they feed and silk spun by them. In the latitude of Washington, D. C., it takes the bagworm a full year to complete its life cycle.

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[13] *Thyridopteryx ephemeraeformis* Haworth.

Control.—Several forms of parasitic insects prey on the bagworm, keeping its numbers within harmless bounds during most years. From time to time, however, this check fails to operate, and then artificial measures of control must be resorted to.

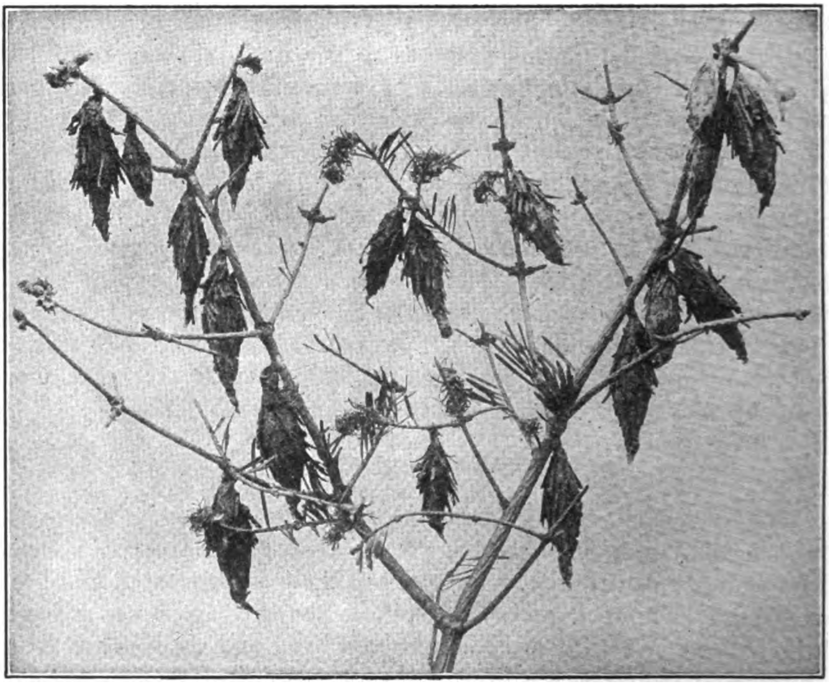

FIG. 17.—Twig of conifer completely defoliated by bagworms, showing bags in various stages of development. (Photo by Paine.)

It is clear from the seasonal history of the insect that if, wherever practicable, the bags be picked off the trees during the winter and burned, so many eggs will have been destroyed that the damage the following season will be limited to the caterpillars from the eggs in the few overlooked bags. A better practice than burning the bags, however, would be to confine them in a bag made of sheer or coarse material and suspended from the ceiling of an outhouse, thus allowing the issue and escape of parasites they may contain, confining the bagworms until they die, and protecting the mass from destruction by mice, decay, etc. Where hand picking is impracticable, and especially on evergreen trees, the most efficient remedy is to spray infested trees with lead arsenate (p. 11) while the worms are feeding and, preferably, soon after they are hatched from the eggs in the late spring. For strength of spray and method of applying it see pages 20–30.

The effectiveness of the campaign against this pest will be in direct proportion to the extent to which the immediate neighborhood participates in it.

A full account of the bagworm is given in Farmers' Bulletin 701 of this Department which will be sent on request as long as the supply lasts.

CATALPA SPHINX.[18]

Recognition of work.—Catalpa trees, the only kind attacked by this insect, are often found having their leaves rapidly devoured by caterpillars which, when full grown, are conspicuously yellow and black striped, 3 inches long, with a short horn near the hind end of the body (fig. 18, *c*, *e*, *f*, *h*). Caterpillar droppings beneath a catalpa tree are another indication of their presence. In some seasons the leaves are completely stripped off entire trees or even groves by this insect.

Habits and seasonal history.—Around Washington, D. C., the insect completes two generations annually, three or four in the extreme South. On attaining full growth the caterpillars of the fall generation crawl down the trunk of the tree and into the ground where they pupate and spend the winter in that stage (fig. 18, *j*). Late the following spring the large grayish brown moths (fig. 18, *k*), known as catalpa sphinx or catalpa hawk moths, issue from these, mate, and lay their eggs (fig. 18, *a*) in batches up to about a thousand on the underside of leaves, and sometimes in smaller batches on stems and branches. The young caterpillars hatching from these feed in groups for some time before scattering (fig. 18, *b*, *b*,). They molt before reaching full growth and pupating, and vary considerably in the markings, as shown in the illustration (fig. 18, *e*, *f*).

Control.—Normally, natural agencies, such as small wasplike and flylike parasitic insects and insectivorous birds, keep this insect in check, so that it is not seen in a given locality for from one to several years. In some parts of the South the catalpa is grown specially for the purpose of attracting the sphinx moth, for its caterpillars are highly esteemed there as bait for fishing. Occasionally, however, natural agencies fail to exercise satisfactory control and then the artificial killing of the caterpillars with poison spray, like lead arsenate, becomes necessary. The method of application of the spray is given on pages 20–30.

Farmers' Bulletin 705 contains a full account of this insect and will be sent on request as long as the supply lasts.

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[18] *Ceratomia catalpae* Bdv.

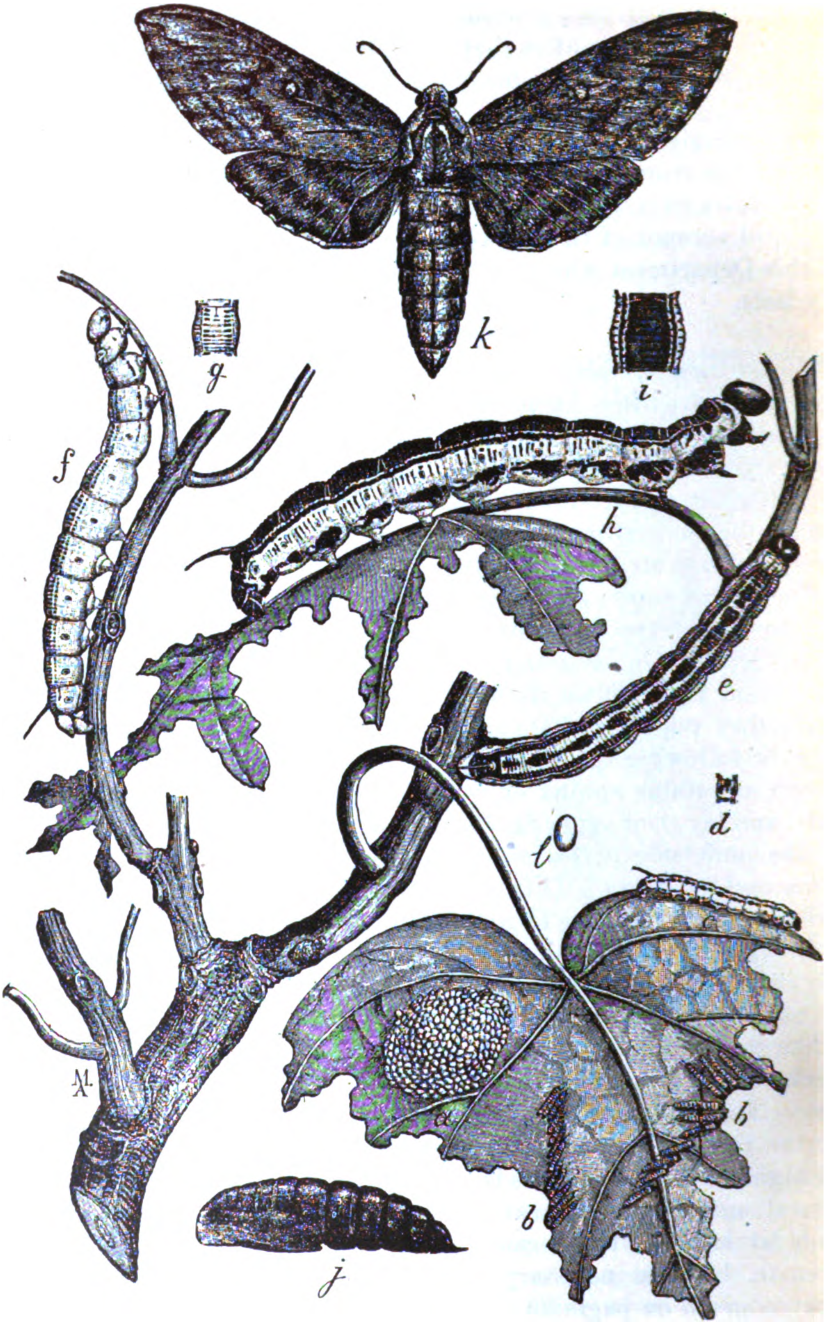

FIG. 18.—Catalpa sphinx: *a*, Egg mass; *b*, *b*, newly hatched larvæ; *c*, larva one-third grown; *d*, dorsal view of joint of *f*; *h*, full-grown dark larva; *i*, dorsal view of joint of same; *j*, pupa; *k*, moth; *l*, egg, enlarged. All natural size, except *l*. Marx del. (Howard and Chittenden.)

FOREST TENT CATERPILLAR.[14]

Manner and amount of damage it does.—Although the sugar maple is its favorite food in the North and oak in the South, the forest tent caterpillar will feed on almost any deciduous tree. Like most native insects it is very abundant and causes serious injury only during spells of two or three consecutive years. During these years, however, it is capable of completely stripping the foliage of deciduous trees over hundreds of square miles. The stopping of trains, due to tracks made slippery by crushed masses of caterpillars which had

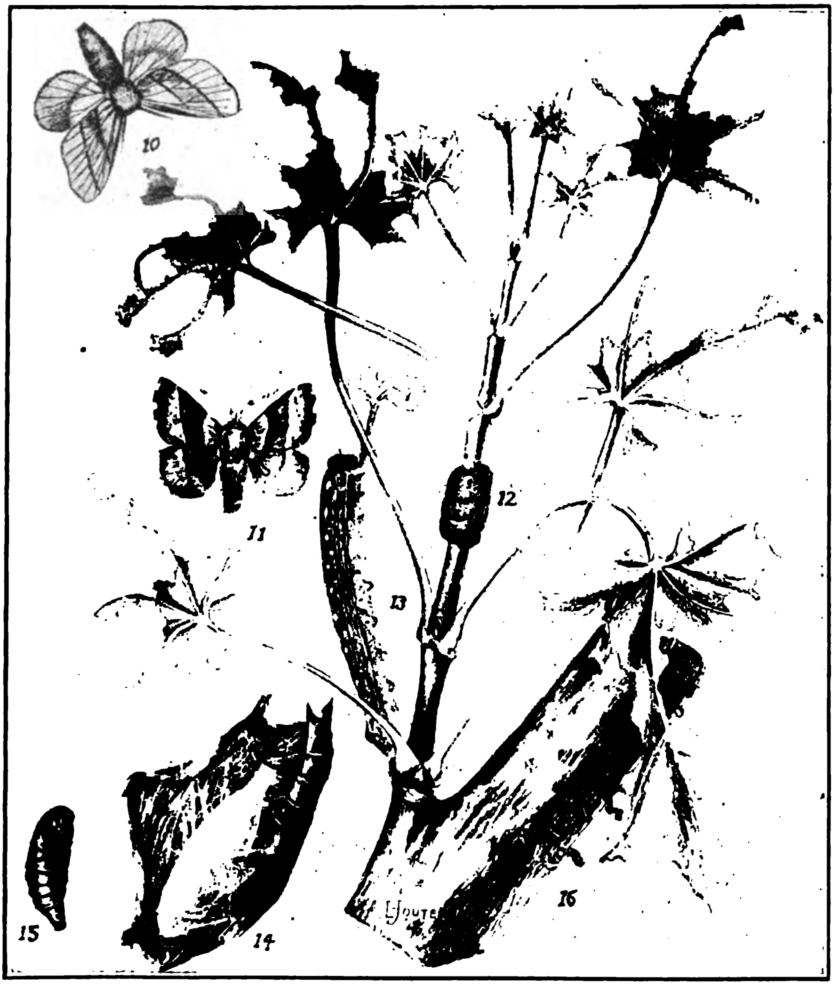

Fig. 19.—Forest tent caterpillar: *10,* Female moth with wings expanded; *11,* male moth with wings expanded; *12,* egg belt encircling twig; *13,* side view of full grown caterpillar; *14,* cocoon in leaf; *15,* pupa; *16,* cast skins of caterpillars. (Felt.)

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[14] ***Malacosoma disstria*** Hübn.

wandered in search of suitable feeding or transformation grounds, has been frequently reported.

How to recognize its presence.—In early summer leaves of hardwood trees or shrubs may show signs of having been eaten by caterpillars with blue head and silvery, diamond-shaped spots down the middle of the back (fig. 19, *13*). When not feeding, these caterpillars cluster on the trunks and large limbs. In a wind they drop to the ground or hang from the tree by silken threads.

Seasonal history and habits.—On approaching full growth, about early June, many of the caterpillars abandon the tree and settle in sheltered places for pupation (fig. 19, *14*). Stones, fences, and wood piles serve their purpose. They remain in this state (fig. 19, *15*) about two weeks and early in July the pupæ turn into moths (fig. 19, *10*, *11*). A little later the females lay their eggs in bands of about 150 around slender twigs (fig. 19, *12*). By fall the young caterpillars are fully developed within the eggs, pass the winter thus, and emerge the following spring about the time leaves begin to unfold.

Remedial measures.—Between the spells of abundance this insect is kept in check by natural agencies, chiefly parasitic and predacious insects and birds as well as unfavorable weather conditions.

Destruction of egg masses, caterpillar clusters, and pupæ in season, either by hand picking and burning or by daubing with creosote or spraying with kerosene emulsion or any of the standard miscible oils on the market, will aid materially in checking the pest. Finally, in the care of choice trees and where the necessary apparatus is available early spring spraying with lead arsenate (p. 11) of the trees known to be infested, if thoroughly done, will effectively check injury for the season.

SPRING CANKERWORM[15] AND FALL CANKERWORM.[16]

Character and extent of injury.—Caterpillars, which because of the peculiar loop they make of their bodies are variously known as "measuring worms," "spanworms," or "loopers" (fig. 20), are frequently found devouring the leaves of forest and shade trees of the eastern United States. Of the numerous species of loopers the cankerworms are among the few species that attack both fruit and shade or forest trees and occasionally become so numerous as completely to defoliate trees on large areas. While as a rule healthy trees replace their foliage, repeated defoliation frequently leads to attack, especially on oaks, by bark and wood boring insects, which habitually thrive on weakened trees and ultimately cause their death. The fall cankerworm is the species usually injurious on shade trees, the spring cankerworm being principally an orchard insect.

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[15] *Paleacrita vernata* Peck.

[16] *Alsophila pometaria* Harr.

Appearance and seasonal history.—The cankerworm is the caterpillar stage of a moth and comes from an egg laid by the female moth, which is always wingless. The eggs of the fall moth are from 50 to 150 in number, flowerpot shaped, and laid in regular rows and compact patches which are generally exposed in rings around twigs near the ends of branches. Those of the spring moth are egg shaped and are laid in irregular batches beneath bark scales. At the time the first leaves expand in the spring these eggs hatch into caterpillars, which attain full growth in about four weeks (about June) and by a silken thread descend to the ground, there pupating a few inches below the surface. From these pupæ the moths of the fall species usually emerge and lay eggs late in the fall or during warm days in winter. The males are winged, the females wingless. Soon after emerging the latter crawl up near-by trees and bushes to deposit their eggs.

Natural control.—Cankerworms are subject to attack by a variety of insect enemies. Climbing ground beetles (fig. 1, p. 6) devour many caterpillars bodily. Small parasitic wasps and flies lay their eggs in and on the caterpillars and in the eggs of the moth, and the ensuing grubs kill even greater numbers of them. Together these insects usually succeed in keeping the cankerworms in check, but if these fail, the cankerworms become seriously injurious.

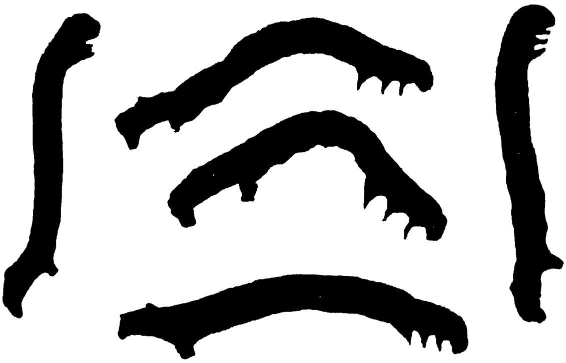

FIG. 20.—Full grown caterpillars of the spring cankerworm. (Quaintance.)

Artificial control.—It is impractical to attempt to combat these insects on trees in the forest, but shade trees can be protected as follows: (1) Advantage may be taken of the winglessness of the female by keeping the tree banded (p. 17–20) with some sticky substance or cotton bands to prevent her from ascending the trees to deposit her eggs. Such bands are most effective where applied toward the end of September and maintained in the spring until the end of May. These bands also prevent the worms that come from the undergrowth from ascending the trees. (2) Where banding has been neglected and evidence of heavy infestation is indicated by numerous perforations in the opening leaves, the foliage can be saved by prompt spraying with lead arsenate (p. 11).

ELM LEAF-BEETLE.[17]

How injurious.—The elm leaf-beetle (fig. 21, *b*) feeds on all species of elm, but the common English elm is its favorite. Wherever it is established and abundant it may, under favorable conditions, keep the elms in a constant state of partial or complete defoliation and eventually lead to their death. Hundreds of elm trees of all ages are known to have died as a result of continuous defoliation by it and subsequent attack by bark-boring insects.

Evidence of infestation.—From the time the buds burst in the spring until the leaves are fairly grown the leaves show irregular holes made by the beetles. Later in the season more of the injured leaves are skeletonized from below (fig. 21, *a*) by yellowish black to blackish yellow larvæ (fig. 21, *d*, *e*, *f*) up to half an inch in length, which may also be observed crawling along the trunk. Clusters of 5 to 20 or more orange-yellow, elongate-oval, tapering eggs standing on end (fig. 21, *c*) in two or three irregular rows occur on the underside of leaves, and naked orange-colored pupæ (fig. 21, *g*) in crevices and under scales on the bark and on the ground at the base of trees.

Seasonal history and habits.—The winter is passed in the adult or beetle condition in any suitable shelter. When the buds begin to swell in the spring the beetles issue from their winter quarters, mate, and feed upon the leaflets. When the leaves are fairly well grown the females begin their egg laying. In about a week the eggs hatch into larvæ, which begin to feed at once. Larvæ reach full growth in 15 to 20 days and transform to pupæ, which, 6 to 10 days later, change to beetles. In Washington two generations are produced annually, the eggs of the second generation appearing in July.

Control.—Whenever there is evidence that the insect is present in large numbers, spray the trees with lead arsenate (p. 11) just after the buds have burst and again two weeks later. Aim to spray the underside of the leaves. Rains soon after spraying may necessitate third and fourth applications of the poison to keep the trees fresh and green. Destroying the pupæ at the base of trees by digging up and exposing to weathering or by pouring hot water or thick soapsuds over them will assist in keeping the beetle down.

Simultaneous community action, by individuals cooperatively or by the local government, is indispensable in the work of combating this insect, because unless all trees in a community are treated at the same time the results will be unsatisfactory. Cooperative action is advisable because elm trees are usually large and require costly spraying apparatus. Treatment of individual private trees by the community outfit should be arranged for, in order that no trees may be left untreated.

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[17] *Galerucella luteola* Müll.

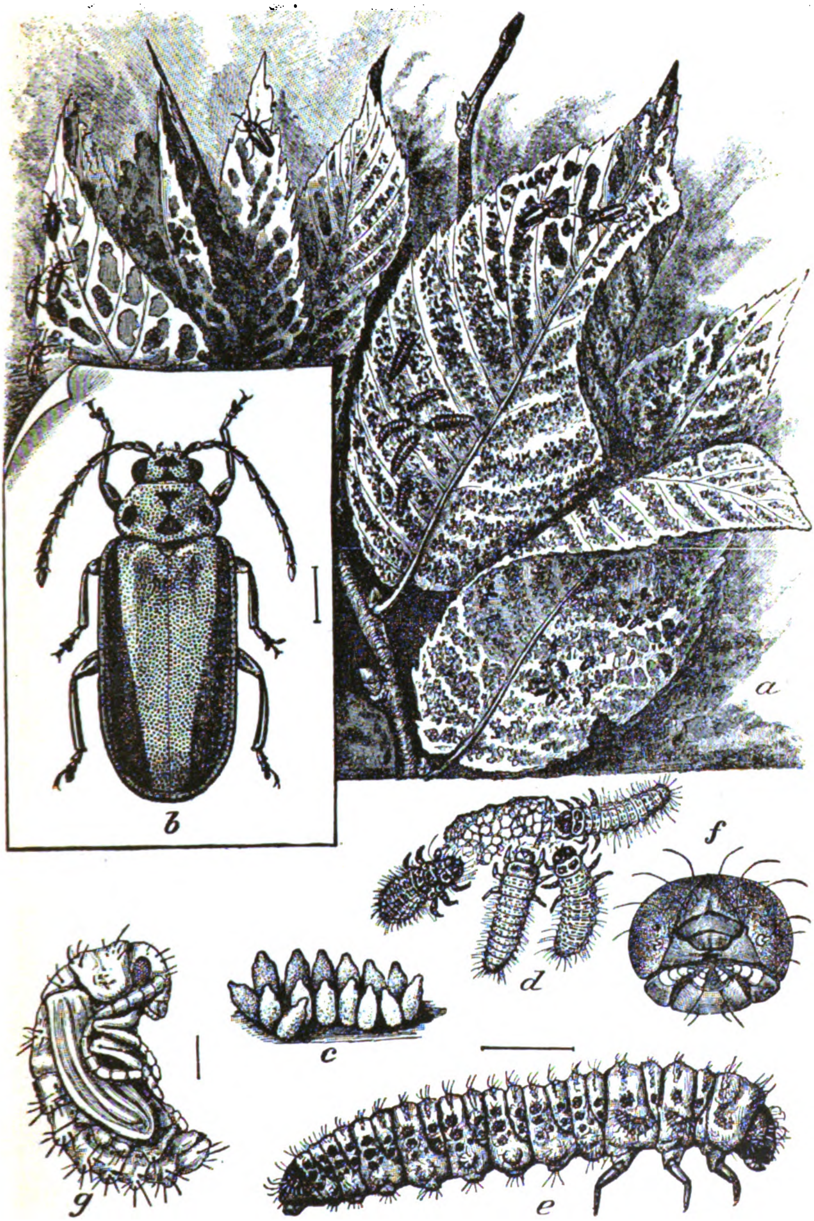

FIG. 21.—The imported elm leaf-beetle: *a*, Foliage of European elm showing method of work of beetle and larva; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *c*, full-grown larva; *f*, mouth parts of full-grown larva; *g*, pupa; *a*, Natural size; *b*, *c*, *d*, *e*, *g*, greatly enlarged; *f*, still more enlarged. (Howard.)

FALL WEBWORM.[18]

Recognition of work.—In the latter part of summer, trees are often found bearing on the limbs conspicuous webs (fig. 22) inclosing skeletonized, usually brown leaves and numerous hairy caterpillars. These are the tents of the fall webworm. The unsightly nests mar the appearance of the trees and, in years of abundance, defoliation of whole rows of trees may be caused by these worms.

Habits and seasonal history.—In Washington, D. C., the fall webworm completes two life cycles annually; less to the north and more to the south. It passes the winter in the pupa state in sheer silk cocoons (fig. 23) in such places as among sticks and rubbish at the surface of the ground, in cracks and crevices of tree boxes and fences, under doorsteps, and on basement walls. In May the pupæ change to moths (fig. 23) which lay their eggs in flat batches of 400 to 500 on the underside of leaves. The young worms, hatching from the eggs, feed in colonies, webbing first one leaf, then several together, and eventually covering sometimes all of a good-sized limb. These

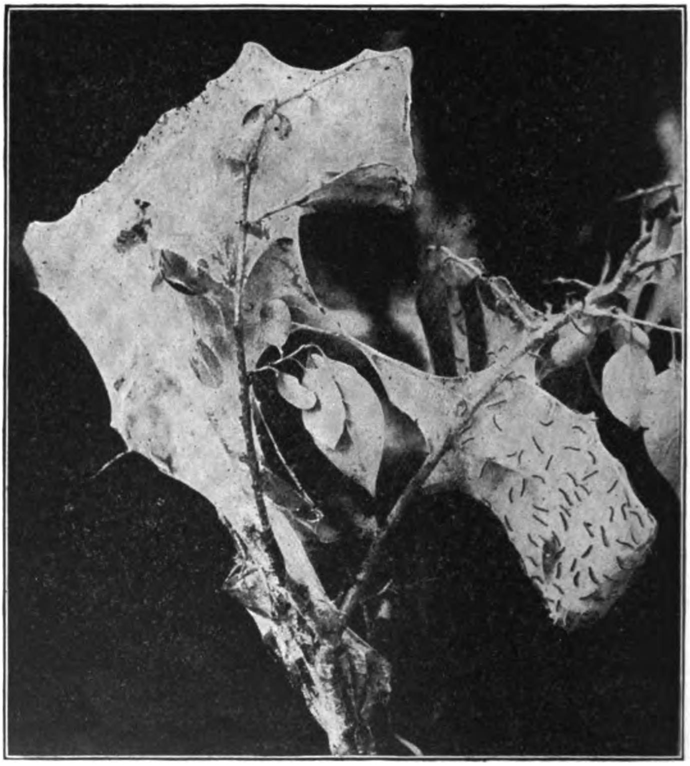

FIG. 22.—The fall webworm: Web and caterpillars. (Gill.)

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[18] *Hyphantria cunea* Drury.

worms attain full growth in July, leave the web, and crawl down the trunk of the tree to pupate. Late in August the year's second crop of their tents is in evidence.

Control.—Natural agencies, and particularly parasitic and predacious insects, usually keep the fall webworm in check. When they become excessively abundant they are invariably attacked by a variety of insect enemies and by a veritable epidemic of diseases which destroy great numbers of the caterpillars, so that they are usually numerous not more than two years in succession.

The most practical remedies against the fall webworm are the destruction of the cocoons, burning the tents, and spraying the infested trees with lead arsenate (p. 11). The methods to be employed are the same as those recommended for the tussock moth.

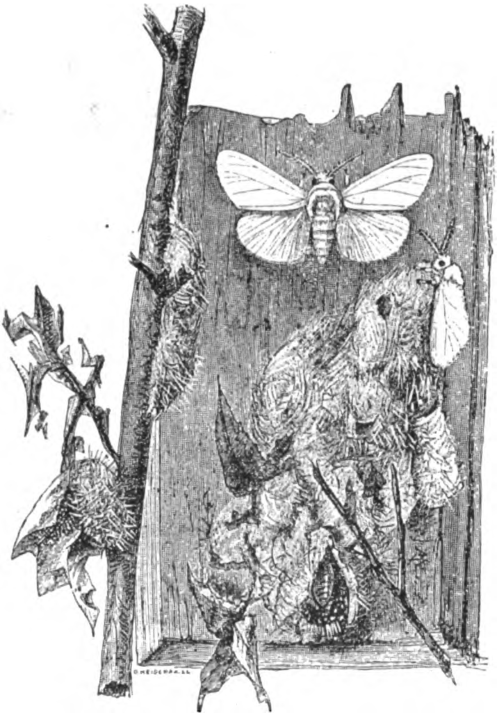

FIG. 23.—Fall webworm: Moths and cocoons. Natural size. (Howard.)

WHITE-MARKED TUSSOCK MOTH.[19]

How injurious.—The white-marked tussock moth is one of our worst shade-tree pests. Under favorable conditions it is capable of increasing to enormous numbers, and its caterpillars may completely defoliate the shade and park trees of a community. Excepting conifers, it attacks almost every variety of tree, and especially poplar, soft maple, elm, alder, birch, and willow. It is most destructive in cities. The caterpillars are given to migration, and the cocoons made by them may be located in almost any place that offers some measure of shelter. It is not abundant every year, being in the meantime kept in check by natural agencies, principally parasitic insects.

Signs of infestation.—From September until the following spring, conspicuous, glistening white, frothy-looking egg masses (fig. 24, *h*) may be observed, mostly low down on the trunk of the tree or on the main limbs. In the spring and summer, leaves partly or entirely eaten by the caterpillars are in evidence. These caterpillars when full grown are more than an inch in length, with red head, three long black plumes at the extremities of the body, and four yellow, brush-like tufts with two red spots behind them on the back (fig. 24, *a*). Cocoons and egg masses (fig. 24, *i*, *k*) occur on the bark of the trunk, branches, and occasional leaves in localities where more than one generation is produced annually.

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[19] *Hemerocampa leucostigma* S. & A.

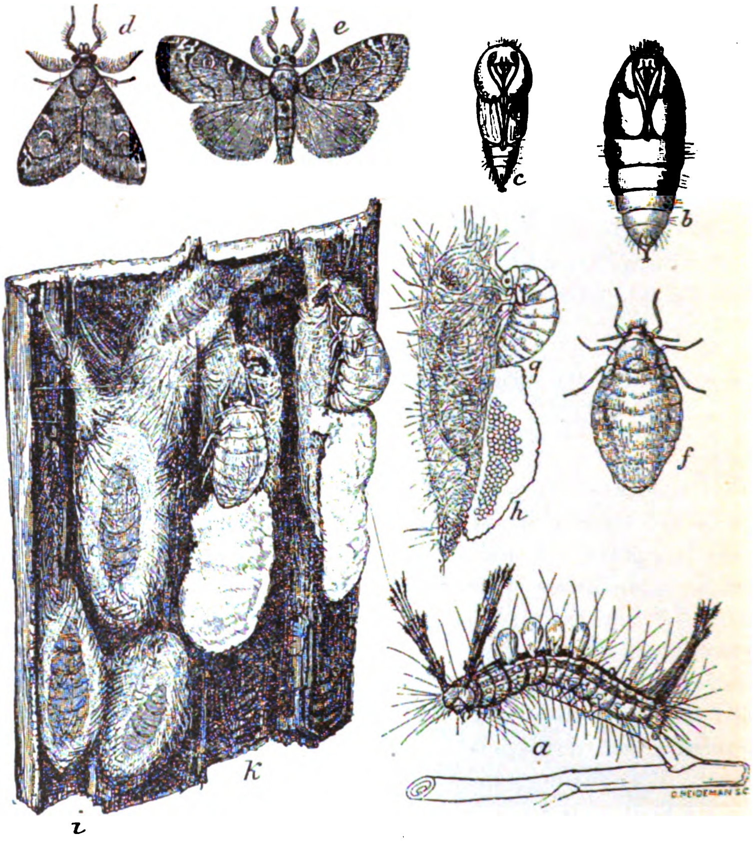

FIG. 24.—White-marked tussock moth: *a*, Larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs. All slightly enlarged (Howard.)

Seasonal history and habits.—From the overwintered eggs the caterpillars hatch in April and May and immediately begin to skeletonize the leaves, later eating holes through them, and finally devouring all but the main veins. Often they may be observed swinging from the tree on a silken thread, and, when caught by wind or passing objects, are transported to other trees. They remain as caterpillars from a month to five weeks, shedding the skin five times in the course of their growth. When nearly full grown they are great travelers, especially from defoliated trees. When full grown the caterpillars spin delicate grayish cocoons of silk, mixed with hairs from their bodies, and within these cocoons they transform to pupæ (fig. 24, *b*, *c*) and, about two weeks later, these change into moths (fig. 24, *d*, *e*, *f*) of which the females are wingless. Mating and egg laying take place soon afterwards. Three generations of the insect are produced annually in Washington, D. C.; two or only one north of that city.

Remedies.—Destroy the eggs in the winter either by hand picking or scraping them off and burning, or by spraying or dabbing with creosote oil, mixed with turpentine to keep it liquid in winter. As soon as injury by the caterpillars is noticed, spray infested foliage with lead arsenate (p. 11). Hand picking or any simple device will do for treatment of the eggs. For spraying purposes a spray pump is necessary, and the size of the equipment will vary with the amount of work to be done. A barrel pump mounted on a horse-drawn cart with one or two 50 to 100 foot leads of garden hose and a 10-foot bamboo rod with a spray nozzle at the end will do for a small town. Cities will find advantage in horse or motor-drawn power spray pumps. The catalogues of reliable spray-pump manufacturers, giving detailed information, are procurable in most seed, pump, or hardware stores and should be consulted.

Essentials of successful control.—Thoroughness, concerted community action, and cooperation are essential for success. Leave as few surviving eggs or caterpillars as possible. Treatment of a tree here and there, now and then, protects no trees, not even those treated. All or most trees must be treated the same season, whether this be done by citizens individually or as a community organization. The trees attacked are usually large. Where spraying must be resorted to, the requisite apparatus is too expensive for the average individual, and can be bought (or hired) and operated only cooperatively, either through local governments or other civic organizations.

LOCUST LEAF-MINER.[20]

Evidence of work and seriousness.—About the time the locust leaves become full grown they are often observed to turn brown, as if fire scorched. Entire trees and groves of locust may assume this appearance. But aside from marring their appearance the injury to the trees is generally less real than apparent. No later than the following spring the trees are sure to put out a fresh, healthy set of leaves, as if nothing had happened.

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[20] *Chalepis dorsalis* Thunb.

Cause of injury.—The locust leaves turn brown mainly because the green tissue within them is being hollowed out—"mined," we call it—by the flattened grubs (fig. 25, *b*) of this beetle; while the blister-like effect on them is produced by the surface feeding pits made by their parents. The parents of these grubs are about one-fourth inch long; they are flattened, orange-red beetles (fig. 25, *a*) with an area along the middle of the back, the head, appendages, and underside black, and the wing covers deeply pitted. This is the stage in which the winter is passed. In the spring, about May, in the District of Columbia, they appear on the leaves, feed, and begin laying eggs in batches of from 3 to 5. From these the grubs hatch and immediately penetrate to the inside of the leaf which they hollow out. On attaining full growth these grubs change to pupæ (fig. 25, *c*) which, in turn, change to adults that come out. These also feed on the leaves and thus help to complete their destruction. There is apparently but one generation produced annually in the latitude of the District of Columbia.

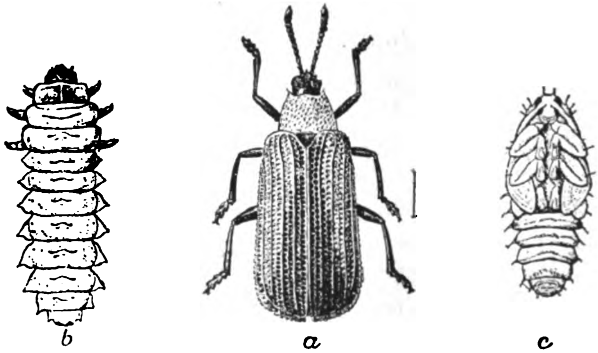

FIG. 25.—Locust leaf-miner: *a*, Beetle; *b*, larva; *c*, pupa. Five times natural size. (Chittenden.)

Remedy.—It is only specially prized trees that are worth treating, and on these an application of lead arsenate (p. 11) as soon as the leaves appear early in the season will kill the grubs as they issue from the eggs and before they penetrate the leaf epidermis, and thus the injury will be stopped.

GREEN-STRIPED MAPLE WORM.[21]

How injurious.—Some years the green-striped maple worm is a troublesome insect on maple trees, especially silver and swamp maples. In the absence of these, however, it has been found to feed on and defoliate other trees. It is capable of completely denuding the foliage twice or even three times during the same season, not only of entire trees but of entire rows and groves of them. Aside from disfiguring the trees for the time being, the defoliation also weakens them.

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[21] *Anisota rubicunda* Fab.

The insect and its habits.—When full grown this maple worm is a smooth caterpillar (fig. 26, *d*, *e*) about 2 inches long, pale yellowish green in color, striped lengthwise with dark green, and having a pair of long black horns just back of the head and a number of black pegs along the sides and at its hind end. These caterpillars enter the ground, there changing to pupæ (fig. 26), *f*), from which the moths issue in about two weeks. The moth is a woolly-bodied, pink-shaded, pale yellow insect with a wing spread of about 2 inches (fig. 26, *a*). After mating the female lays on the underside of leaves about 150 eggs (fig. 26, *b*, *c*), from which the caterpillars hatch in about 10 days. The insect overwinters in the pupa state in the ground and the first generation of moths issues from them in May or June, depending on the locality, which also determines whether two or three crops of the caterpillars are produced annually. The green-striped maple worm is a native of North America, and this accounts for the periodicity of its abundance. In the intervals between outbreaks it is kept in check by its natural enemies, including birds and parasitic insects. It is

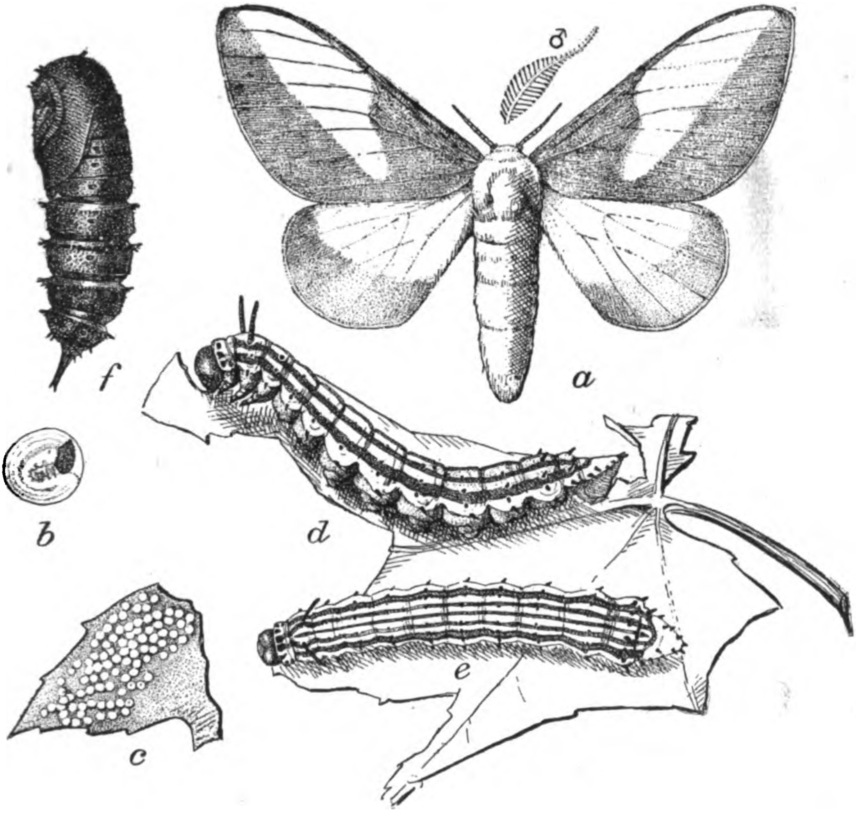

FIG. 26.—The green-striped maple worm in all its forms: *a*, Female moth and antenna of male moth; *b*, egg showing embryo within; *c*, portion of egg mass; *d*, full-grown larva from side; *e*, same from back; *f*, pupa. Enlarged. (Howard and Chittenden.)

more abundant in the Middle West than in the East, although it is more or less generally distributed east of the 100th meridian.

Remedies.—On specially prized smaller plants some relief from this pest may be obtained by hand picking and destroying the caterpillars. Sizable trees should be sprayed with lead arsenate (p. 11) as soon as the caterpillars appear, to protect them from defoliation. In case of maple groves or suitably located individual trees it has been found possible to protect them from a repetition of defoliation by digging around them a trench about a foot deep, with the outer wall sloping under, and destroying the caterpillars and pupæ that collect in them.

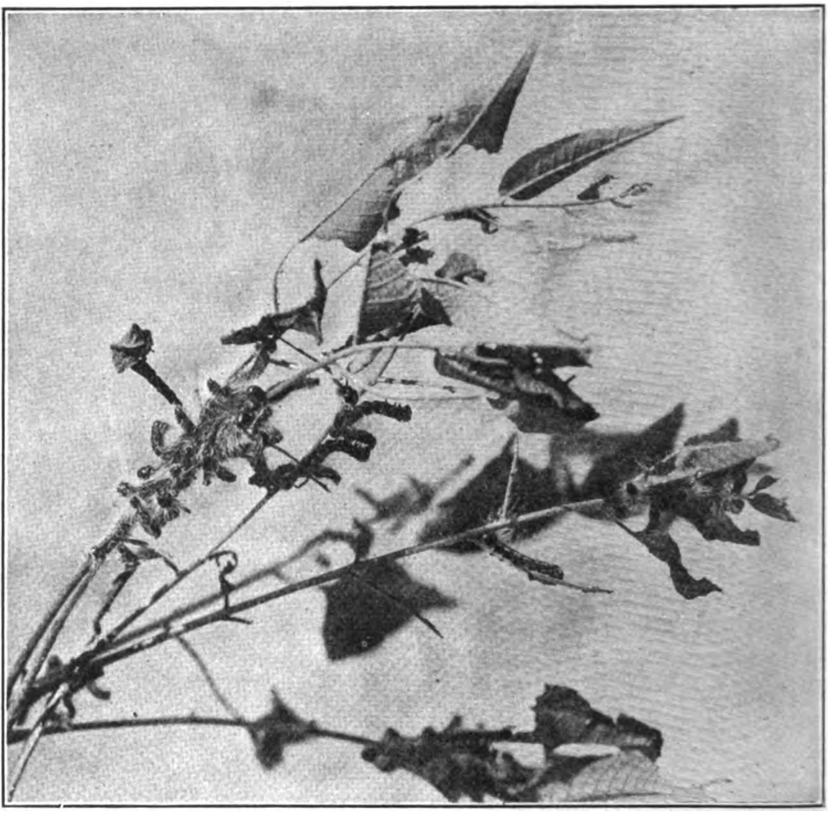

FIG. 27.—Cluster of full grown walnut caterpillars, showing peculiar poses, long hairs, and clustering habit. (Photograph by Cramer, Washington, D. C., Sept. 27, 1919.)

WALNUT CATERPILLAR.[a]

How injurious.—When there are enough of them, these caterpillars (fig. 27) strip walnut trees bare of leaves. Other trees also, especially butternut and hickory, are likely to suffer the same fate.

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[a] *Datana integerrima* G. & R.

Successive defoliation in many instances kills the trees. The walnut caterpillar is more abundant and therefore more destructive some years than others.

How recognized.—When this insect is present pieces of leaves begin to disappear in late summer and early fall, eaten by the gregariously feeding caterpillars, which when full grown are black, covered with dirty gray hairs, and nearly 2 inches in length. When disturbed caterpillars rear at head and tail ends (fig. 27) in an unusual manner. On the trunk and larger branches of infested trees large clusters of caterpillars or their cast skins may be observed.

The insect and its habits.—On maturity the caterpillars crawl down the trunk of the tree an inch or two into the ground and there transform into chrysalids. In this shape they overwinter, remaining in the ground until the following July, when the moths issue from them and lay their whitish eggs in clusters of 75 to 100 on the underside of the leaves selected as food for the caterpillars that hatch from them. The habit of feeding and molting gregariously is a characteristic of this insect.

Remedies.—Collect and destroy the clustered caterpillars feeding on twigs or molting on the trunk and branches. Failing this, and if the facilities are at hand, spray infested trees with lead arsenate (p. 11).

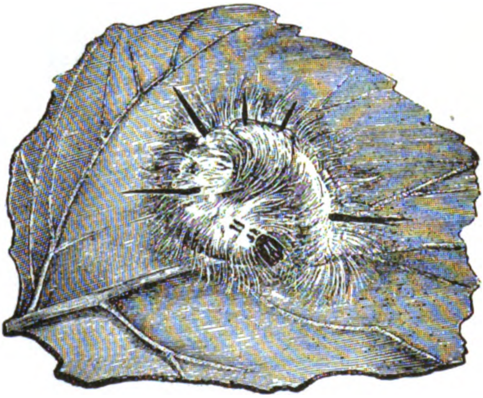

FIG. 28.—Caterpillar of cottonwood dagger moth. (Riley.)

COTTONWOOD DAGGER MOTH.[28]

How injurious.—In prairie regions the caterpillar of the cottonwood dagger moth is a serious enemy of cottonwood and willow trees, which it often strips of foliage. As these trees are important in these regions for purposes of timber and shelter, this defoliation is a serious matter.

The insect and its habits.—The caterpillar (fig. 28) is densely covered with long, soft, drooping, yellow hairs, bears five rather long, stiff tufts of black hairs along the back, and when at rest it lies curled up on the underside of a leaf. When full grown it retires to some cranny where a silken cocoon, intermixed with its hairs, is spun and within it the change to chrysalis takes place.

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[28] *Apatela populi* Riley.

In this form it overwinters and the following spring the pale gray moth emerges from it. The moths are night flyers and lay their eggs on the host plant, one in a place. Two cycles are completed in the course of the year in the latitude of Nebraska.

Remedy.—Spray infested trees with lead arsenate (p. 11).

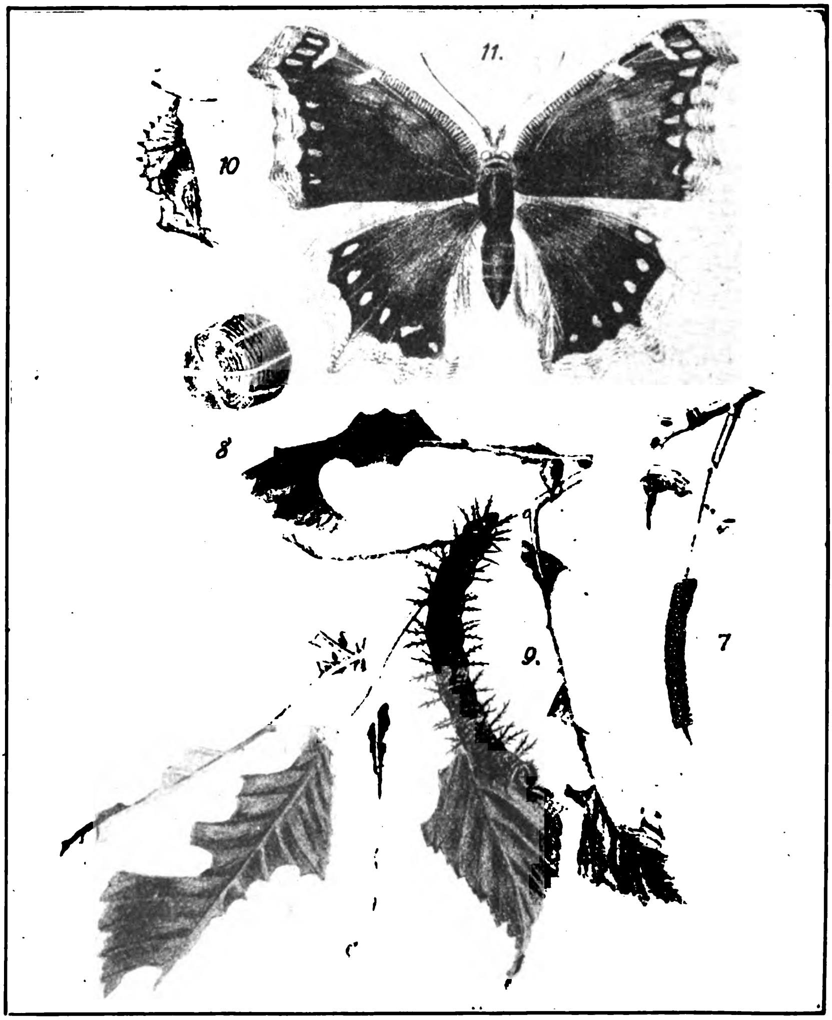

FIG. 29.—Spiny elm caterpillar: 7, Cluster of eggs on leaf stem; 8, one egg, much enlarged; 9, caterpillar feeding; 10, chrysalis hanging from leaf stem; 11, butterfly with spread wings. Egg cluster and caterpillar on elm twig showing characteristic appearance after feeding by the caterpillars. (Felt.)

SPINY ELM CATERPILLAR.[24]

How injurious.—The spiny elm caterpillar feeds on elm, willow, poplar, and hackberry leaves. The amount of injury depends on the number of caterpillars present, but when abundant these are known to defoliate entire branches and trees. In our prairie regions, where trees are so scarce and precious, the injury to willows and poplars is most serious.

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[24] *Euvanessa antiopa* L.

Appearance and habits.—If parts of leaves are missing or entire branches or trees are bare and stocked with black, red-marked, spiny caterpillars (fig. 29, *9*), about 2 inches long, feeding in groups, it is safe to conclude that this insect is the one responsible for the damage. On maturing the caterpillars change to strange looking sea-shell shaped chrysalids (fig. 29, *10*) which may be found suspended from a limb and fastened to it by the small end. After a few weeks the beautiful butterfly, known as the "mourning cloak" (fig. 29, *11*), the first butterfly to appear in the open in early spring, issues and, after mating, lays a batch of from 300 to 400 eggs (fig. 29, *7*, *8*) in a ring about the twig of the food plant. From one to three generations are produced annually. The insect overwinters in the adult stage, the butterflies hiding under rocks and bark scales for protection.

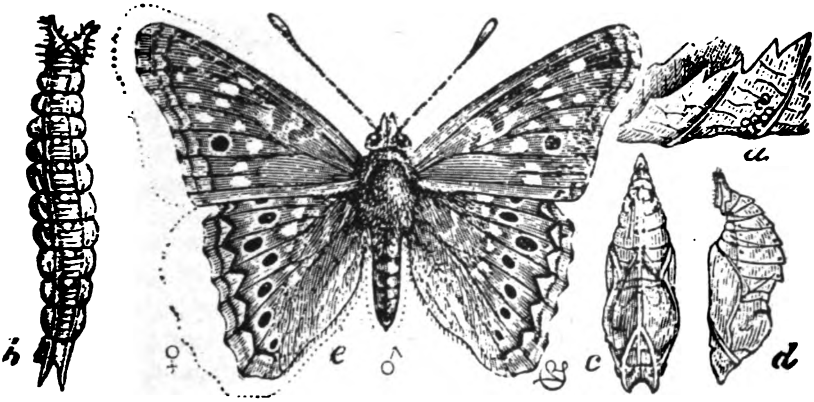

FIG. 30.—A hackberry butterfly, *Chlorippe celtis: a*, Eggs; *b*, larva, dorsal view; *c*, *d*, chrysalis, dorsal and lateral views; *e*, imago, male, dotted line showing form of female. (Riley.)

Remedies.—Spray with lead arsenate (p. 11) as soon as signs of injury are observed. In some cases the twigs with clustered caterpillars may be cut off and the caterpillars destroyed by crushing, burning, or dipping in kerosene.

HACKBERRY BUTTERFLIES.[a]

How injurious.—The caterpillars of these butterflies feed on hackberry leaves wherever these trees grow and often greatly mar their appearance. As the hackberry is extensively grown as a shade tree in the Middle West, the injury of these insects assumes lively importance.

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[a] *Chlorippe celtis* Bdv. and *C. clyton* Bdv.

Appearance and habits.—Attention is drawn to the insect by hackberry leaves which show signs of being eaten away, and green caterpillars with pale spots and lines along the back and projections on head and rear (fig. 30, *b*) are found on the underside of leaves. The caterpillars change to chrysalids (fig. 30, *c*, *d*) in folded leaves and later to russet-gray, brown-spotted buterflies (fig. 30, *e*), which, after mating, lay their eggs singly (in one case, fig. 30, *a*) or in batches of 300 to 500. Two generations are produced annually, the second-stage caterpillars of the last generation falling to the ground with the leaves they are on and passing the winter there.

Remedies.—The leaves may be raked up and burned in the fall or the infested trees sprayed with lead arsenate (p. 11) while the caterpillars are feeding.

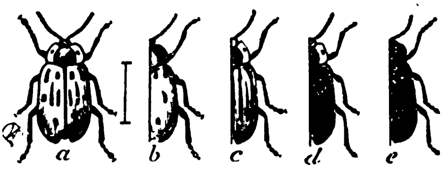

FIG. 31.—Streaked cottonwood leaf-beetle (*Melasoma scripta*), showing variation in markings. (Riley.)

COTTONWOOD, POPLAR, AND WILLOW LEAF-BEETLES.[28]

How injurious.—Poplar, cottonwood, and willow leaf-beetles are particularly injurious because their adults as well as young or larvæ derive their nourishment from eating the leaves of these trees, and, as they produce from three to five generations annually, they are capable of keeping the trees in a constant state of defoliation. They are most prevalent in the Northern States, are occasionally seriously injurious, especially to basket willow in the East, and are an almost constant drain on the health of these trees in the Middle West, where tree life is so scarce and precious that injury to it is intolerable.

How recognized.—Infestation is indicated by leaves of these trees bitten part way through in places and entirely through in others early in the season, and entirely consumed later by spotted, soft-bodied, short, stoutish grubs and spotted or striped, half-inch long, hard-shelled beetles (fig. 31), mostly on the underside of leaves where also batches of yellow or reddish eggs standing on end and pupæ are to be found. The young when disturbed emit a milky fluid.

Habits.—The overwintering beetles appear in the spring as soon as growth starts on these trees and promptly begin eating this growth. After feeding awhile they lay clusters of eggs from which the soft-bodied grubs hatch and begin eating away the underside of the leaf. When after several molts they are full grown, they partly cast the last skin and pupate in it fastened to the leaf. "Hangers" they are called in some sections of the country, where the beetles issuing from them are known as "hard shells." During the growing season the generations overlap, owing to more rapid development of some and slower growth of others, so that all stages, from egg to adult, may be found at the same time.

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[28] *Melasoma scripta* Fab., *M. lapponica* L., *M. tremulae* Fab., and others.

Remedy.—Spray with lead arsenate (p. 11), especially as soon as growth starts. Direct the spray against the underside of the leaves and for smooth leaves add soap (p. 14) so that the spray will stick to the leaves.

LARGE ELM AND WILLOW SAWFLY.[37]

How injurious.—More commonly in the Middle West, and locally in the East, the large elm and willow sawfly has been observed completely defoliating willow and elm trees and groves, and occasionally poplar and other trees. As stated in connection with other defoliating insects occurring in the Middle West, such outbreaks are pathetic in view of the solicitude with which trees are regarded there and the disappointment entailed when they are found undergoing despoliation.

How recognized.—Occasionally the tops of these trees look as if overrun by fire from the girdling of the bark of the twigs by the adult sawfly (fig. 32, *b*). More often, however, their leaves are found blistered by eggs or larvæ in pockets (fig. 32, *a*) or eaten by cylindrical, coiled, yellowish-white worms (fig. 32, *e*, *e*) with a black line down the middle of the back.

Habits.—The caterpillar-like insects that eat the leaves attain full growth about July or August and descend to the base of the tree where they spin a tough, coarse, silken cocoon (fig. 32, *f*) among the débris or just below the surface of the ground and overwinter there. The following spring they change to pupæ (fig. 32, *g*, *h*) and the adults, rather large, flylike insects, with four clear wings (fig. 32, *i*), appear about May, mate, and the females make slits in the fleshy part of the leaves and thrust their eggs (fig. 32, *c*) into these pockets and from these the young worms (fig. 32, *d*) come out to feed soon after hatching.

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[37] *Cimbex americana* Leach.

Remedies.—Winter burning the rubbish and breaking up the ground at the base of infested trees should destroy many of the insects. Where practicable, hand picking of worms or infested leaves early in the spring is a great help. Finally, lead arsenate (p. 11) is always a reliable stand-by against these insects.

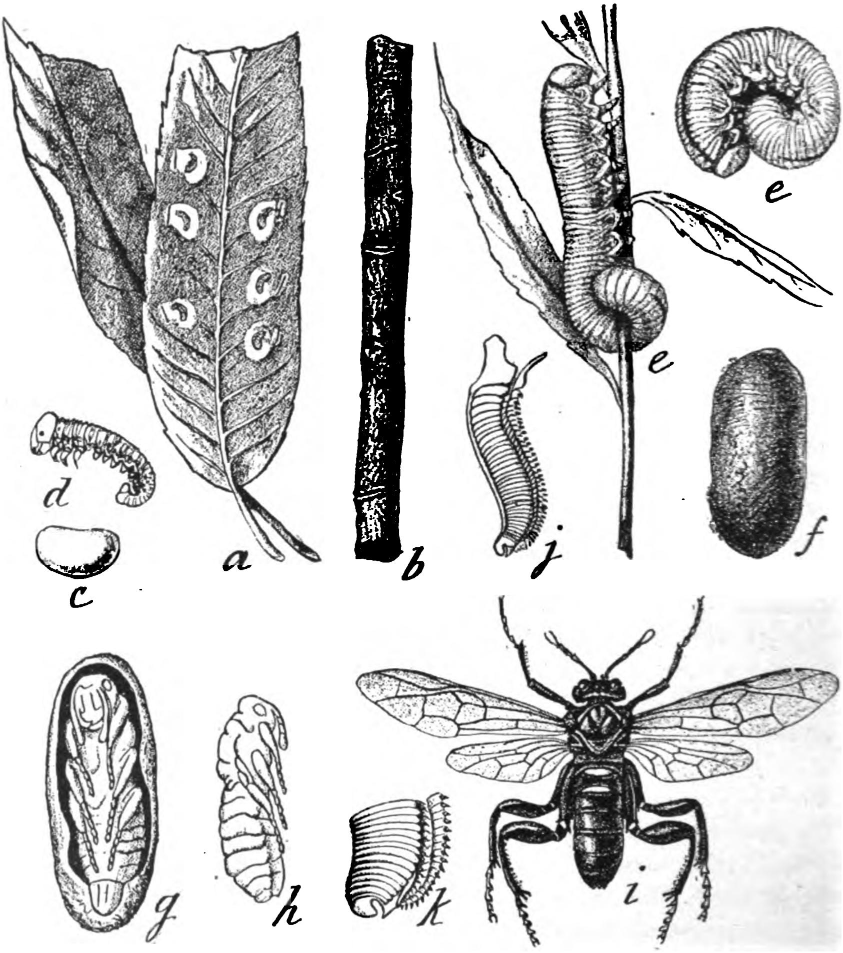

FIG. 32.—Large elm and willow sawfly: *a*, Willow leaves showing location of eggs; *b*, twig showing incisions made by adult; *c*, egg; *d*, newly-hatched larva; *e*, *e*, mature larvæ; *f*, cocoon; *g*, open cocoon showing pupa; *h*, pupa, side view; *i*, mature sawfly; *j*, *k*, saw of female; *c*, *d*, *j*, *k*, much enlarged, the rest less enlarged. (Riley.)

BARK, WOOD, AND TWIG BORING INSECTS.

GENERAL.

Boring insects secure their nourishment either by extracting it from chips of bark and wood that they bite off and swallow as they burrow or by feeding on the sap, depending on whether they feed in the dead wood or in the sapwood. Their injury to shade trees is along two directions: (1) When their burrows do not kill the tree or limb, they admit, on the body of the boring insect or in the moisture that penetrates their excavations, diseases which rot and ultimately disable or kill it; (2) when their burrows in that life-giving layer located between the bark and wood extend around the limb or tree, the circulation of sap between roots and leaves is arrested and death ensues quickly. In the case of timber the burrows also reduce in grade the lumber cut from it or make it entirely worthless. Moreover, the work of these insects is hidden from view, so that too often it is discovered when it is too late to save the tree. For these several reasons the presence of borers in trees is particularly dangerous and must be guarded against most carefully.

Because they feed and live most of their lives out of sight they are beyond reach of the usual poison or contact insecticides. The use of certain preparations, like poisoned miscible oil or kerosene emulsion or carbon disulphid, as will be pointed out under the respective insects, is practicable in a few instances. In the majority of cases, however, the healthy trees can be saved only by opportune sacrificing of those that are badly infested, or, in some cases, by stimulating the growth and well-being of those just invaded by these insects. Protection of shade trees from boring insects rests, therefore, almost wholly on preventive measures. Trees well nourished, protected from all manner of injury, and otherwise well cared for are more nearly immune to attack by boring insects than those not so cared for. In a neighborhood, community, grove, or park where a majority of the individuals of a given borer are destroyed the remaining trees will successfully resist attack and be saved thereby.

SUGAR-MAPLE BORER.[23]

How injurious.—In some sections of the country, especially along roadsides in New York State, the sugar-maple borer is regarded as the most serious enemy of this tree. It attacks trees in full vigor, killing large limbs and entire trees. The serious damage is done by the grubs, especially when their burrows meet so as to girdle the tree or limb.

Signs of borer presence.—When the borer is present the trees show dead limbs here and there; ridges and dead spots appear on the bark (fig. 33, *1*, *1a*), or naked scars on the branches and trunk. especially near the base of the larger limbs, sometimes with oval holes three-eighths to five-eighths inch in diameter, and "sawdust" (fig. 33, *6*) at the base of the tree or in bark crevices; the foliage on a large limb suddenly wilts, dries up, and dies with sap and small masses of frass flowing from some point. Any one or a combination of several of these signs indicates the work of this borer.

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[23] *Plagionotus speciosus* Say.

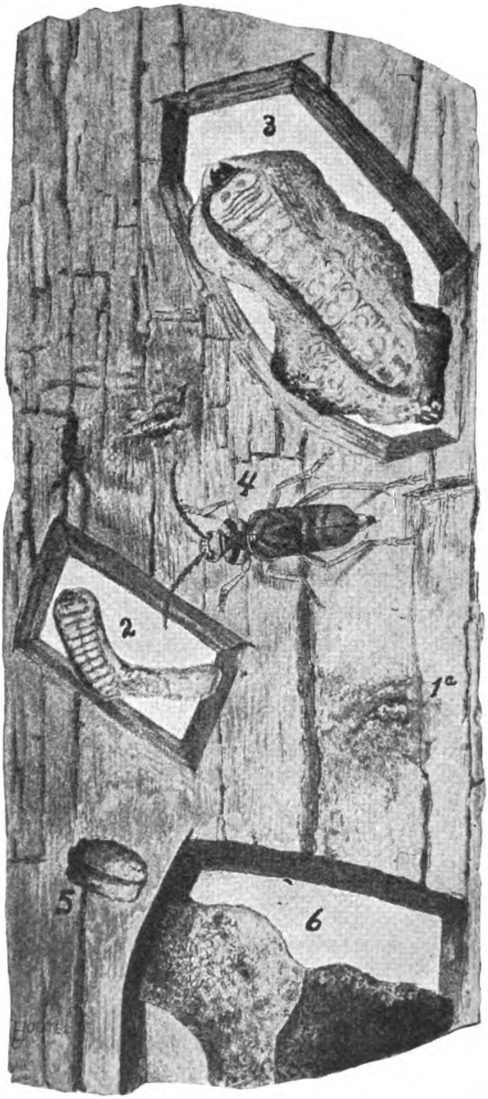

FIG. 33.—Sugar-maple borer and work: *1*, Place where egg was laid; *1a*, another more than normally discolored and showing borings thrown out by borer; *2*, grub in September from egg laid the same season; *3*, grub nearly full grown; *4*, beetle; *5*, hole through which beetle escaped; *6*, borings packed in burrow. (Felt.)

Description, seasonal history, and habits of the insect.—The borer is a whitish grub (fig. 33, *2*) about one-half inch long with brownish mouth parts, located at the end of the burrow in the sapwood, or about 2 inches long and of similar shape and color in a larger burrow somewhat deeper in the wood (fig. 33, *3*). The parent insect is a beetle about 1 inch long, stout, shorthorned, black, brilliantly marked with yellow (fig. 33, *4*). It comes out between June and August through oval holes in the bark (fig. 33, *5*).

Remedies.—Dying trees or limbs should be cut down and burned before June, so as to kill the grubs in them before they have transformed into adults and emerged. Specially prized trees should be examined in the fall and spring for signs of the insect, and the borers killed either by cutting them out (in which case cut surfaces should be covered with creosote-tar mixture or good white-lead paint (see p. 14–15), or by forcing a flexible wire to the end of the burrow, or by injecting carbon disulphid (p. 14) into the holes and promptly plugging them with clay, putty, or similar substance. Where facilities are at hand the trunk and larger branches of the trees may be sprayed in the late summer with poisoned kerosene emulsion (p. 12–13) or miscible oil (p. 12), which will reach and kill the borers that have just penetrated the bark. Care should be taken to avoid spraying the foliage, as this is injured by these solutions.

ELM BORER.[39]

Signs of attack.—Elm trees only are subject to injury by this borer. The leaves of tops or ends of branches of infested trees turn brown and fall in summer, after which tops and branches here and there die, as shown by their failure to leaf out in the spring, and in two or three years the entire tree is killed. Thorough search of the trunk and larger branches of dying trees discloses patches of dead, readily peeling bark with burrowing roundheaded grubs beneath it (fig. 34, *1*). This is the form of the insect that does the injury, and when the limb or tree is girdled by the burrows (fig. 34, *3*) its doom is sealed.

How destructive.—Trees growing in unfavorable environment, particularly in cities, are most subject to attack by this borer, and then apparently only when the trees have been previously weakened by some other agency. Hence it becomes epidemic only occasionally, but on such occasions it is apt to wipe out the trees on entire blocks of some communities.

Distribution.—The elm borer probably occurs generally throughout the northeastern United States.

Description and seasonal history.—The parent insect is a gray, long-horned beetle (fig. 34, *4*), about one-half inch long and marked with red lines and black spots. Its flying period is between May and August. At that time the eggs are laid singly or in groups on the bark, where they hatch into tiny, footless grubs which promptly tunnel through it to the cambium layer. Here they excavate continuously wider cavities to accommodate them as they grow. These tunnels, when they reach around the tree or limb, girdle and kill. The full-grown grub (fig. 34, *1a*) is white, a little over an inch in length, thickest in front, but the head is only about half as wide as the segment immediately behind it. It is not definitely known how long the insect remains in the grub stage, but on reaching full growth it cuts out a cell beneath the bark and pupates in it, looking very much like a mummified beetle (fig. 34, *2*). In the spring, about May, these pupæ change to adult beetles which cut round holes in the bark and come out.

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[39] *Saperda tridentata* Oliv.

Prevention of attack.—Once a tree is badly attacked nothing can save it and the axe is the best remedy. If this is applied during the winter or early spring, before the beetles begin to emerge, to all trees or infested branches of a community, and the wood is promptly burned, many of the beetles will be destroyed and the rest of the trees saved. As indicated under "How destructive," removal or prevention of the agencies causing the primary weakening of the trees will go far toward preventing the beetles from inflicting the final fatal blow. This preventive work can best be called scientific arboriculture, and involves proper nourishment of the tree and its protection from injury.

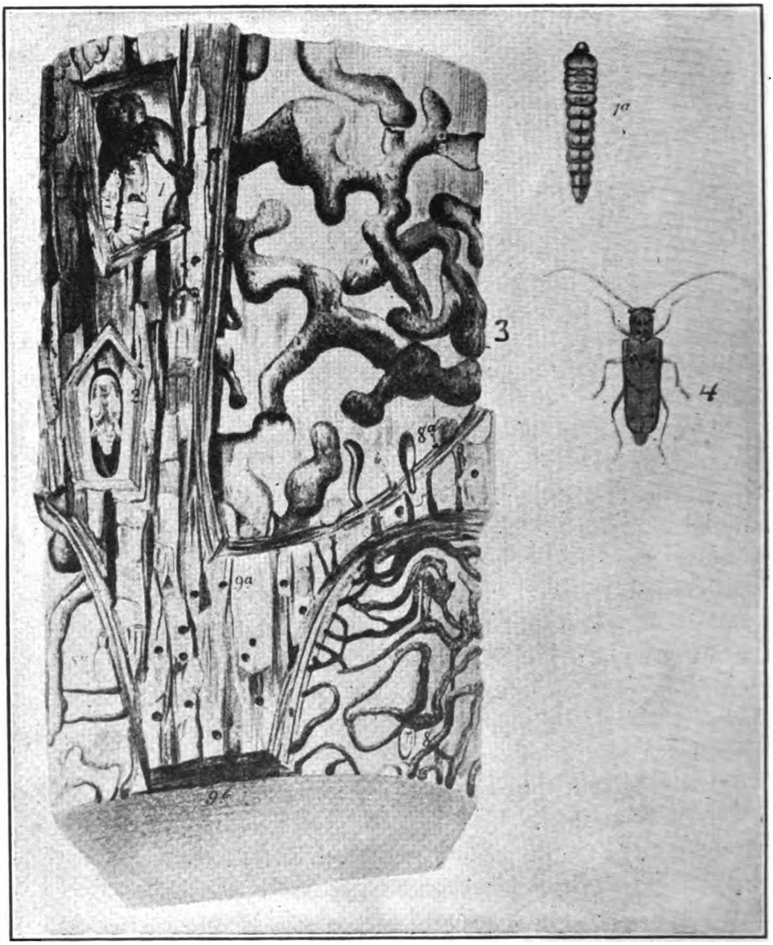

Fig. 34.—Elm borer and work: *1*, Grub within its burrow; *1a*, grub extended; *2*, pupa within its cell just under the bark; *3*, burrows of the grub exposed by removal of the bark; *4*, adult beetle. (Felt.)

LINDEN BORER.[30]

How injurious.—This insect apparently attacks only linden, but on this it is common and occasionally quite injurious. It is more or less generally distributed over the eastern United States.

How recognized.—Toward the end of summer tips are found killed and the green bark of growing shoots, leaf stems, and larger veins on the underside of leaves are eaten. This is the work of the beetles and is quite noticeable when the insect is abundant. Burrows made by a slender grub occur under the bark and deep in the wood (fig. 35, *11*, *16*) of the trunk nearer the ground, in exposed roots, and in lower limbs.

Habits of the insect.—The beetles (fig. 35, *15*), which are long-horned with six black spots on the middle of the back, issuing out of holes (fig. 35, *12*) in the bark, begin to appear in May, and after feeding awhile the females make with their jaws slight incisions in the bark and lay two or three eggs in each. One female lays about 90 eggs. The grubs (fig. 35, *16*) that hatch from these make the burrows mentioned above and, after an undetermined length of time, change to pupæ and then to beetles which leave the tree through holes in the bark throughout the summer.

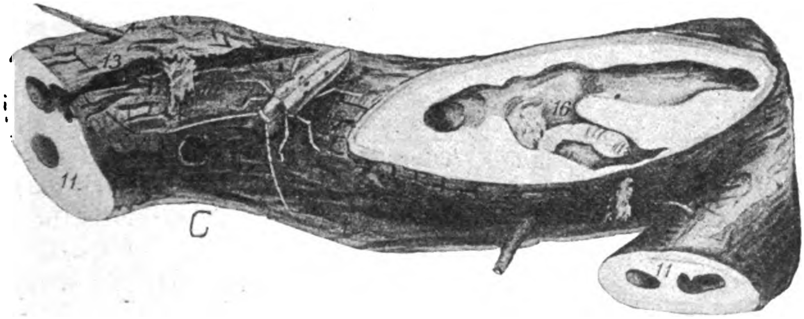

FIG. 35.—Linden borer and work: *11*, Burrows in cross section; *12*, circular exit hole of the beetle; *13*, wound made by borer; *14*, frass thrown out by larva; *15*, beetle; *16*, grub in the gallery under the bark which was cut away. (Felt.)

Remedies.—On valuable trees the injury may be checked by digging out the borers. Probing with wire, injections of carbon disulphid (p. 14), and spraying with poisoned miscible-oil solution (p. 13) in the late summer are other serviceable means of killing this borer. Heavily infested and badly damaged trees are best cut and burned during the winter.

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[30] *Saperda vestita* Say.

ASPEN BORER.[31]

Character of damage.—The aspen borer is generally quite destructive to poplar trees and particularly so to aspen and cottonwood throughout the United States, especially in the Middle and Western States. Malformation of the trees, death of limbs and often the entire plant, and riddling of the main trunk with large holes which cause the tree to break off in the wind, are the usual results of the attack.

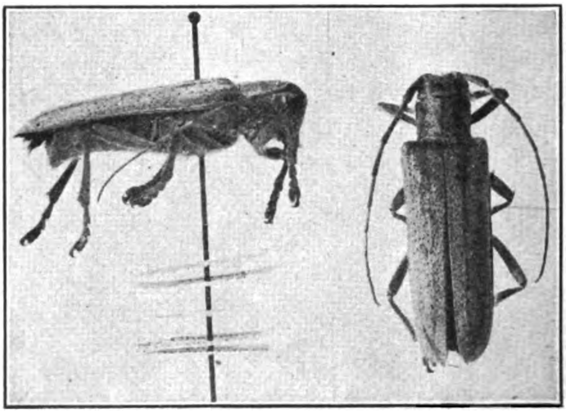

Fig. 36.—Aspen borer: Side and top views of beetle. Enlarged. (Hofer.)

External evidence of infestation.—In June and July irregular scars occur on the main trunk, especially around the crotch of branches, from which sap exudes and fibrous boring dust is thrust out. Later or older evidence of infestation is the enlargement of holes, extrusion of more or larger bits of frass, and often the death of limbs. The adults (fig. 36) are rarely seen because they feed on the young twigs and lay their eggs at night.

Description and habits.—The boring stage or larva (fig. 37) of the poplar borer is a yellowish, cylindrical grub which can be distinguished from all other insects boring in poplar by the presence of numerous fine, short, hard points on a plate immediately back of the head. It hatches from an egg laid in a scar on the bark by a grayish cylindrical beetle (fig. 36) with numerous brown spots over the body. The eggs are laid during the period from May to July, the young larvæ mining during the first year beneath the bark, and during the succeeding two years deep in the wood.

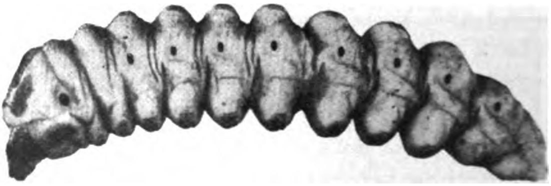

Fig. 37.—Aspen borer: Grub, much enlarged. (Hofer.)

Remedies.—For shade trees and small plantations or groves spraying of infested trunks during the late summer months with poisoned kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12–13) is recommended for killing the very young larvæ in the outer bark. On valuable trees some measure of relief may also be obtained by painting the eggs with creosote or carbolineum or by digging out and killing the young borers in early fall as they begin to tunnel their way into the wood. Heavily infested and badly damaged trees should be removed and burned or exposed to drying during the winter.

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[31] *Saperda calcarata* Say.

For a full account of the aspen borer see Farmers' Bulletin 1154 which will be sent on request.

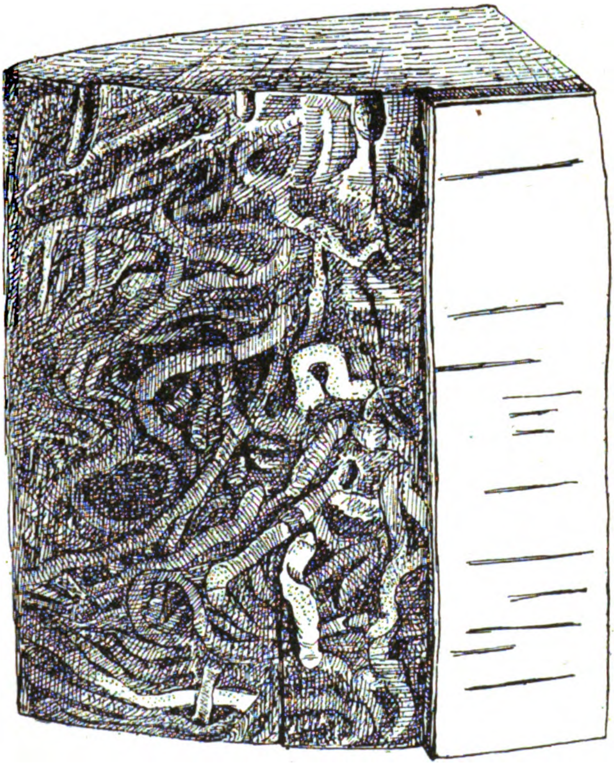

FIG. 38.—Work of bronze birch borer on trunk of white birch; bark removed to show larval galleries. Somewhat reduced. (Chittenden.)

BRONZE BIRCH BORER.[a]

Character and extent of injury. — During the past 20 years or so the birch trees of many city and private parks have died. As the top branches die first, the vitality of the trees gradually deteriorates and finally, one or two years later, the entire tree succumbs. This condition is usually due to the work of the bronze birch borer.

Evidence of infestation.—The following are signs that the trees are infested: (1) Characteristic reddish or rusty brown spots or discoloration on the white bark of the trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows (fig. 38) in the bark of the wood; (2) ridges (fig. 39) in the bark on the branches which often develop over the burrows of the insect; (3) dying tops.

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[a] *Agrilus anxius* Gory.

Seasonal history and habits.—The borer itself (fig. 40, *c*), i. e., the stage of the insect mainly responsible for the damage, is a slender. flattened, footless, creamy white grub, about three-fourths inch long when full grown, which transforms to a small, slender, olive-bronze, winged beetle (fig. 40, *a*) nearly one-half inch in length. This beetle emerges from the trees in May or early June, depending on the location and season, and the female deposits her eggs in crevices on rough surfaces of the bark, several together. These eggs hatch into tiny grubs which burrow their way through the bark, underneath which they tunnel a zigzag course in the bark and sapwood until they are full grown. In the autumn they excavate a chamber in the wood or outer bark and here spend the winter. About April or May the following spring they transform to pupæ, and these into the adults which gnaw their way out, leaving peculiar oval holes in the bark. Their life cycle is thus completed within a year. The beetle attacks birch, poplar, and aspen trees wherever they grow in the United States, being particularly destructive to imported birch in parks and lawns in the Northern States and attacking from slender branches to trunks of trees over 25 years old.

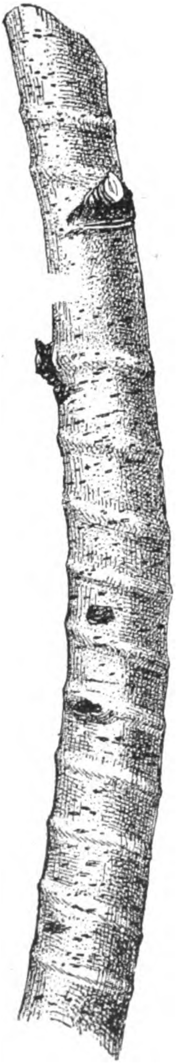

FIG. 39.—Work of bronze birch borer on limb of white birch. Somewhat reduced. (Chittenden.)

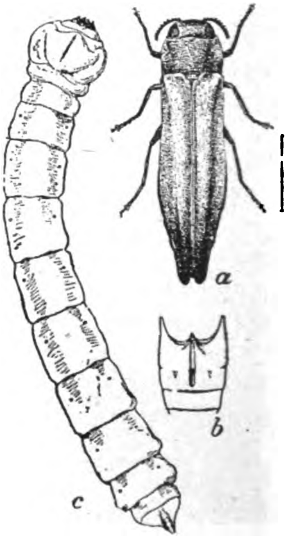

FIG. 40.—Bronze birch borer: *a*, Female beetle; *b*, first abdominal segments of male from below; *c*, larva from above. All enlarged about 3½ times; line at side of beetle shows natural length. (Chittenden.)

Prevention of damage, and control.—Badly damaged trees are not only past saving but are a menace to the trees of the neighborhood still free from attack; therefore trees showing dead tops and other evidences of infestation should be cut down and burned during autumn or winter and *not later than May 1.* A tree cut here and there will not check the ravages of borers. This is a neighborhood or community problem, and to insure that the work is thoroughly done and in good season it must be enforced either by community ordinance or by aroused public sentiment and understanding.

THE PARANDRA BORER.[33]

How injurious.—Although primarily breeding in utility timber, like telephone and telegraph poles, and other structural wood in contact with the ground or in moist situations, this insect is frequently found in the eastern half of the country seriously injuring all kinds of mature shade trees. This injury is at the base, and in windstorms trunks and branches thus weakened break off easily. This insect probably accounts for a greater percentage of destroyed bases of shade trees than any other.

Character of work and habits of the insect.—The adult, a rather large brown beetle, flies during the month following the blossoming of the chestnut, laying large numbers of eggs deep in the heartwood wherever this is exposed. In this wood the grubs live as such for three or four years before changing to pupæ. They feed gregariously, completely honeycombing the wood and packing the mines with granular frass. The oval pupal cell is constructed in the wood, plugged behind with a wad of fibrous frass. Pupation takes place about a month before the adults emerge.

A small wound near the base or in the larger branches of living trees offers a place of entrance for the young grubs which, penetrating the heartwood, continue to feed until nothing remains but a shell of sapwood. Under certain conditions the adults do not emerge but mate and lay eggs in the same cavity in which they are working. Often the wound where they gained entrance heals over and shows no sign of their presence.

Remedies.—As it is very difficult or frequently impossible to locate points on the tree where this insect is working, remedial measures must be directed toward prevention of the injury. All scars, fresh wounds, or injuries exposing the wood should be painted (p. 14–15) or so treated that no decay can start and that they quickly heal. Old cavities should be thoroughly cleaned and filled with concrete, care being taken that all wood showing any trace of grub-made mines is removed.

TWO-LINED CHESTNUT AND OAK BORER.[34]

How injurious.—The sudden death of sickly and healthy chestnut and oak trees is most often traceable to injury by the two-lined chestnut and oak borer, as this is their most serious insect enemy. As high as 75 per cent of these trees have been killed off by it in some areas. In sickly trees the insect is very generally found associated with the shoe-string root fungus, or previous defoliation, and it unquestionably hastens the death of such trees. When weak trees are scarce and the beetles are numerous they may attack perfectly healthy trees and kill them.

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[33] *Parandra brunnea* Fab.

[34] *Agrilus bilineatus* Weber.

Habits and appearance.—The beetles are on the wing in early summer, when they mate and lay eggs, preferably in deep cracks on the bark of the main trunk and branches. Each egg hatches into a flat, bigheaded, milky or yellowish white grub (fig. 41, *c*) which burrows through the bark and, by the time it is full-grown, by fall, it has excavated a burrow up to 3 feet long obliquely and across the grain in the inner bark and outer wood. It spends the winter in a chamber in the outer bark. Late the following spring it changes here to a pupa (fig. 41, *d*) and about two weeks later transforms to the adult, which is a dull or brownish black beetle (fig. 41, *a*) one-fourth to two-thirds inch long with two yellowish lines along the back, which burrows its way out of the tree and begins life in the open as described above. A number of such burrows (fig. 42), side by side around the trunk, girdle the tree and sever the vessels which carry food and moisture between roots and top, and the tree dies in consequence.

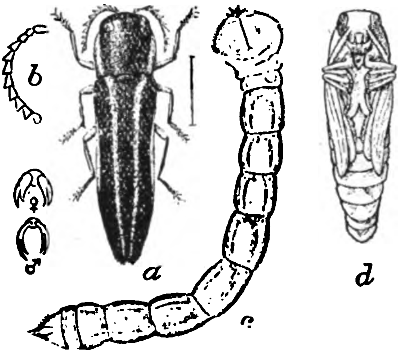

FIG. 41.—Two-lined chestnut and oak borer: *a*, Adult beetle; *b*, antenna of same; ♀, claws of posterior tarsi of female; ♂, same of male; *c*, larva; *d*, pupa. *a*, *b*, *c*, and *d*, Enlarged; *b*, ♂, and ♀, more enlarged. (Chittenden.)

Remedy (applicable only to specially prized, individual, slightly infested trees).—Spray the trunks during fall with poisoned kerosene emulsion (p. 12–13).

Prevention.—In the grove or forest prevention is the only practical means of control. This consists of the following measures calculated to eliminate the beetle's favorite breeding quarters (bark on freshly felled or dying trees and cordwood): Remove and promptly burn, during the fall, winter, or early spring, the bark (the wood may be utilized for any suitable or desired purpose) of all heavily infested, injured, weak, dying, and dead chestnut and oak trees and limbs over as wide an area about the trees to be protected as possible. Thoroughly done, this will kill the grubs in these trees, eliminate the borer's favorite breeding places, and reduce the numbers of the beetles to such an extent that those remaining will be incapable of effecting serious injury. In most cases extension of the area of control operations can be achieved only through cooperative or joint action of adjoining owners, and this must be secured for successful results.

Beetle brood trees left in the area will tend to nullify haphazard control work.

LOCUST BORER.[33]

Character and extent of injury.—The locust borer is the most destructive insect of black or yellow locust in some localities. Perfectly healthy trees are attacked. The wounds it makes in the bark and sapwood stunt their growth. If the attack is severe or continuous for a number of years, the trees, particularly young saplings and branches of larger trees, are killed and their wood is made worthless by the wormholes.

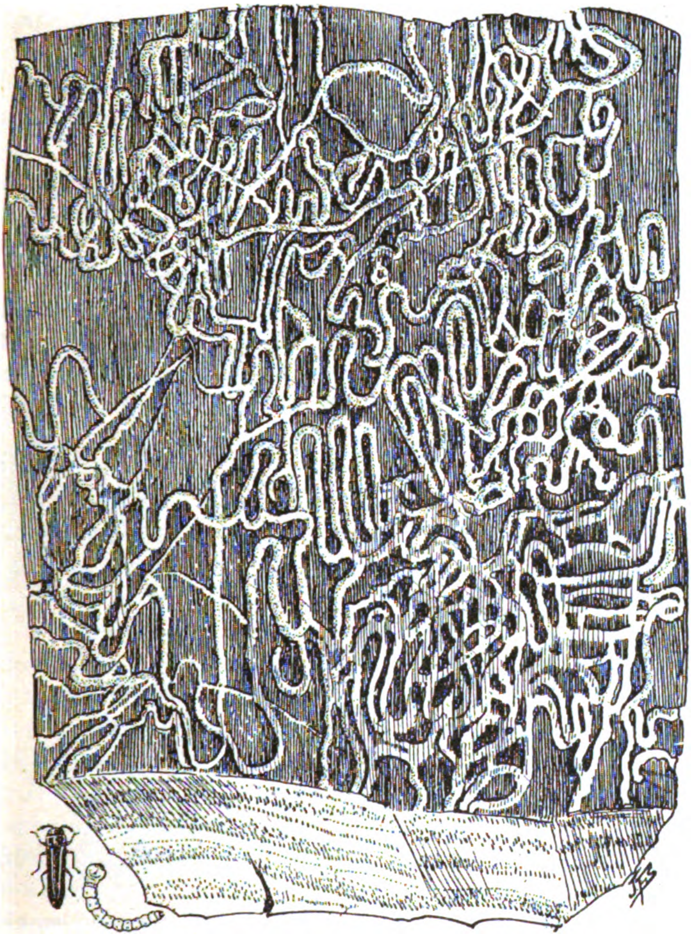

FIG. 42.—Work of two-lined chestnut and oak borer. Section of wood from main trunk of a dead chestnut, showing the larval mines on the outer surface after removal of bark. Beetle and grub at left lower corner. (Burke.)

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[33] *Cyllene robiniae* Forst.

Evidence of infestation.—In April and May brownish boring dust and wet spots are to be seen on the bark of the trunks and branches, and as the season advances wet spots and yellowish boring dust mixed with liquids are present in increasing quantity. Leaf buds fail to open, the foliage is dwarfed or faded and sickly, and branches and small trees break down. The frequent occurrence of the adults in the period from August to October, particularly on goldenrod flowers, indicates the presence of the insect in injurious numbers.

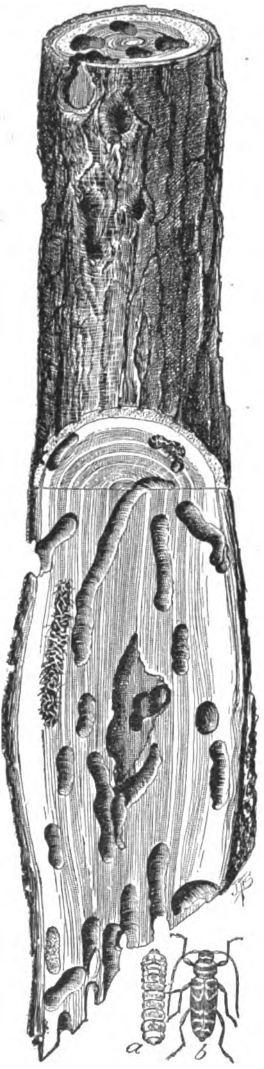

FIG. 43.—Section of trunk of locust tree, dying from injury by the locust borer. Shows burrows of borer in bark and wood; also the larva at *a*, and the beetle at *b*. (Webb.)

Description and habits.—The locust borer is a whitish, elongate, roundheaded grub (fig. 43, *a*). It hatches from an egg laid by a black, longhorned beetle (fig. 43, *b*) with yellow, zigzag stripes. The eggs are laid in crevices of the bark during the period from August to October and the young borers that hatch from them excavate individual cells in the outer layers of the inner, living bark, where they overwinter. In the spring they bore into the wood, where they change to pupæ during July and August and to beetles during August and September, whereupon the beetles bore exit holes and come out to mate and resume the life cycle. This beetle is a lover of and works in the sunlight, therefore shaded trunks and branches are not subject to its attack—a fact which, if borne in mind in connection with the care of locust plantations, will result in the saving of trees. (See Bulletin 787, United States Department of Agriculture.)

Remedy.—For shade trees and small plantations or groves, spray infested trees in the spring, when these trees begin to show green, with poisoned kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12, 13). This will kill the young borers in the bark.

Control.—Cut locust trees for posts, etc., during the dormant season, and peel and promptly burn the bark and branches to destroy the borers in the bark. In May and June (not later than the falling of the locust flowers) cut and burn all badly infested trees.

Prevention.—In localities where it is still absent, guard against introduction of the borer in posts or other products having the bark on. Regularly each year locate and destroy entirely or remove the bark from infested trees. Secure cooperation of neighbors in the work, so far as possible. Finally, allow all the undergrowth possible and keep growing trees untrimmed so that they will be well shaded when the beetles fly. The beetles, being sun loving, will not lay eggs on shaded trees.

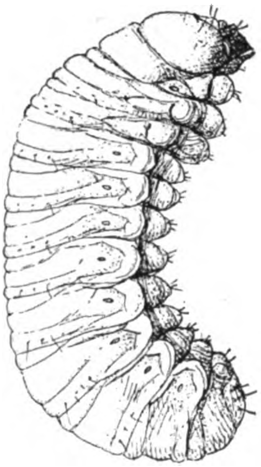

FIG. 44.—Grub of the mottled willow and poplar borer. Enlarged. (Chittenden.)

MOTTLED WILLOW AND POPLAR BORER.[a]

How injurious.—This is a most serious enemy of willow and poplar trees, the limbs and trunks of which it tunnels until they die or break in the wind. It found its way into this country a number of years ago and has since established itself in practically all the Northern States.

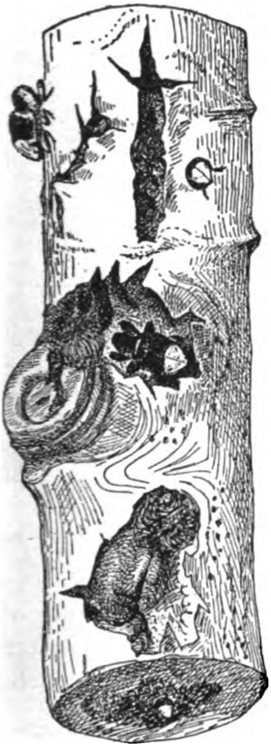

FIG. 45.—Poplar branch showing work of larva and punctures made by beetle of mottled willow and poplar borer (near bottom at right); also beetles. Natural size. (Chittenden.)

How recognized.—Dead or dying limbs, swellings, and dead patches of bark often cracked open on limbs or trunk, fading foliage, and "sawdust" and oozing sap at points of attack are signs of infestation. Fresh punctures made by the beetles while feeding on the younger shoots are also in evidence. Injured twigs, when split open, disclose burrows, mostly along the middle, and within each is a fleshy, white, footless grub (fig. 44) about one-half inch long when full grown.

Habit and appearance.—The grub is usually full grown about June or July, pupates, and turns to the adult, which is a rather stocky, dark colored snout-beetle (fig. 45) about three-eighths inch long, with spots and rear third of the wing covers pinkish white. For a week or two after emerging the beetles feed on the young bark and then the females begin to gouge out cavities in the bark of 2 to 4 year old growth and lay their eggs in them. The grubs hatching from these penetrate the bark and spend the winter directly under it. The following spring they resume feeding and keep it up until full grown, whereupon they bore into the wood, through it to the pith, and make a 3 to 4 inch gallery along that, filling it with wood fiber and pupating at one end of it. Thus the life cycle, although completed within a twelvemonth, extends from one calendar year into the next.

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[a] *Cryptorhynchus lapathi* L.

Remedies.—Cut out and burn all infested wood before May or June, thus preventing the grubs from reaching maturity and propagating. It appears possible also to control the insect by thoroughly coating the bark in July with lead arsenate (p. 11) or by painting trees with kerosene emulsion (p. 12, 13) in April or thereabouts.

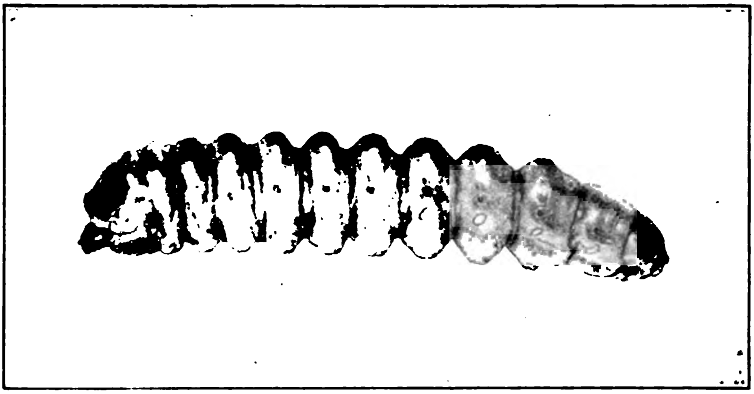

FIG. 46.—The cottonwood borer: Larva, side view. Enlarged. (Milliken.)

COTTONWOOD BORER.[a]

Destructiveness.—In the Middle West the cottonwood borer is very destructive to poplar or cottonwood and willow trees in all stages of growth. The mines of the borer, made at the base of the stem, often girdle the tree, causing its death or so reducing the strength of the wood that it is broken off by the wind.

Evidence of infestation.—Broken-off trees, sickly tops, and collections of shredded boring dust on the surface of the ground beneath the trees indicate the presence of the borers. On removal of the bark at the surface of the ground borer mines are disclosed.

Description and habits.—The cottonwood borer is a yellowish, elongate, cylindrical grub (fig. 46). It hatches from an egg laid by a large, black and white mottled, longhorned beetle (fig. 47). The eggs are laid during July and August in small punctures made in the bark at or just below the surface of the ground, and the borers hatching from them excavate individual mines, first beneath the bark and later deep into the wood, throwing out shredded borings as they work along. Two years of feeding in the tree pass before the borer matures and transforms to a beetle.

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[a] *Plectrodera scalator* Fab.

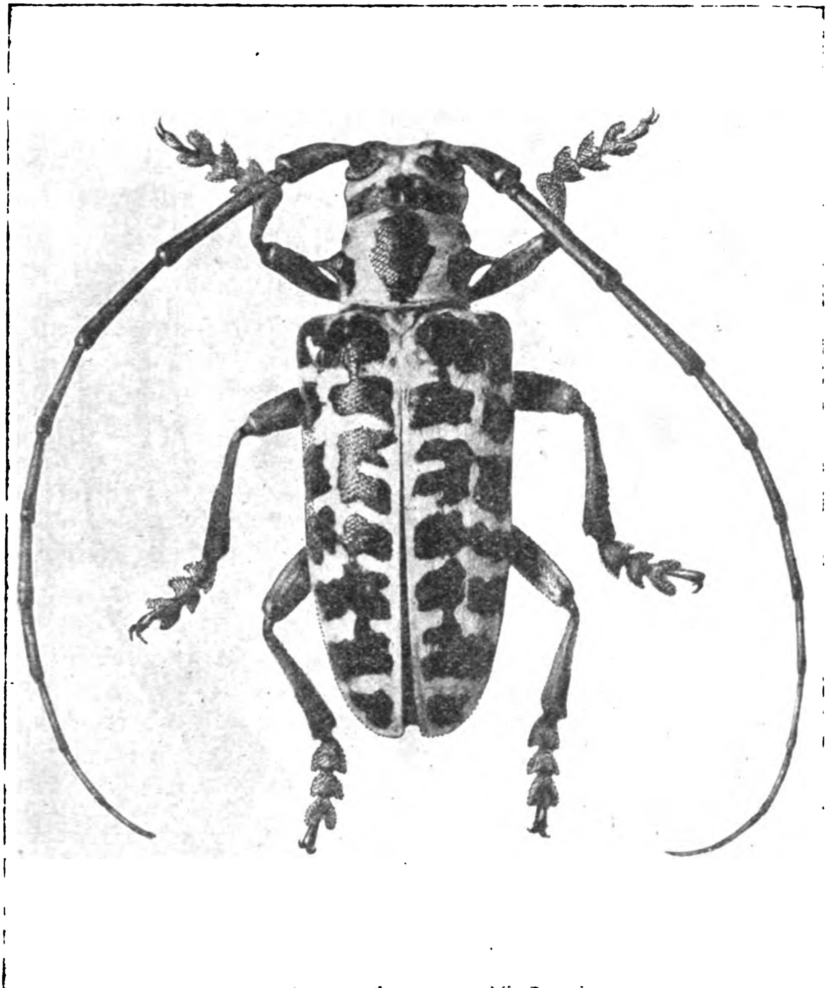

Fig. 47.—The cottonwood borer: Male beetle. More than twice natural size. (Milliken.)

Remedies.—In the case of shade and otherwise valuable trees the borer may be profitably killed either by being dug out while young or by injection of carbon disulphid (p. 14) into the hole showing fresh sap and boring dust, this hole being then promptly plugged with putty, clay, or similar substance. It seems as though the young borers might also be killed by spraying the infested trunk with poisoned kerosene emulsion (p. 12, 13) or miscible oil (p. 12, 13).

Prevention.—A wire screen, up to half an inch mesh, wrapped around the base of the tree so that it reaches about a foot above ground and several inches into the ground, which fits snugly at the top and is an inch or two away from the bark the rest of the way, will prevent the beetles from laying their eggs in it.

LEOPARD MOTH.[38]

Recognition of work.—The death or dying of limbs on otherwise healthy shade trees in cities along the Atlantic seaboard from eastern Massachusetts to southern New Jersey and in the Hudson River Valley is in many cases traceable to the destructive work of the caterpillars of the leopard moth. In cases of severe attack, especially on young trees, growth is checked and, when the trunk is girdled, death follows. In the region of its occurrence the leopard moth has proved to be a most serious menace to shade trees.

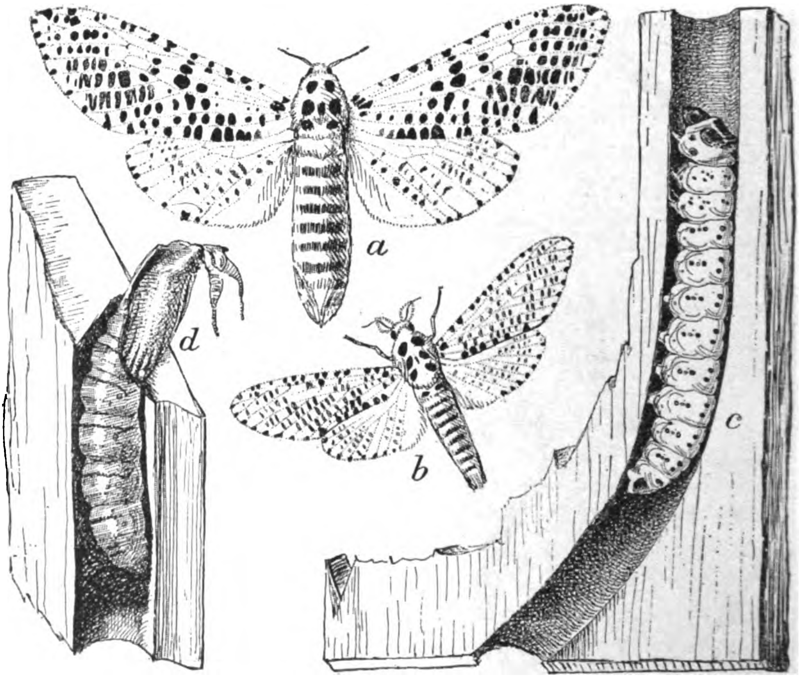

FIG. 48.—The leopard moth: *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Howard and Chittenden.)

Habitats and seasonal history.—The leopard moth was introduced from Europe about 40 years ago, but fortunately its spread has been very slow. The caterpillar of this moth is a wood-boring insect, and feeds on the living wood in branches and trunks of deciduous trees. Evergreens are not attacked. From the time it hatches out of the egg, about two years pass before the caterpillar (fig. 48, *c*) stops growing and changes to a chrysalis within its burrow (fig. 48, *d*). When it becomes mature, which happens during the period between May and September, the pupa or chrysalis forces its way partly out of the burrow (fig. 48, *d*), its skin splits open, and the leopardlike, spotted white moth (fig. 48, *a*, *b*) come out of it. Immediately after mating the female begins egg laying. As many as 800 eggs were observed to have been laid by a single female. The eggs are laid singly and in groups of three or more in crevices of the rough bark, from which they hatch about 10 days later and the issuing larvæ begin to burrow their tunnels toward the heart of the wood, thus completing the two-year life cycle.

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[38] *Zeuzera pyrina* Fab.

Methods of control.—No easy method of wholesale destruction of this insect is known at present. Badly infested trees and limbs should be cut and *burned promptly* lest the borers migrate from them to the healthy wood. Many young and highly prized trees, showing only a few burrows, have been saved from death and even further injury by killing the borers in them with carbon disulphid injected into the burrows (p. 14). A flexible wire in many cases can be employed to advantage for killing borers in their burrows by probing. Clean culture, prompt attention, and simultaneous community work are necessary for effective control. Farmers' Bulletin 708 contains full information on this insect.

CARPENTER WORM.[30]

How destructive.—Although it rarely kills trees, the large burrows up to one-half inch wide made by the carpenter worm in the very heart of trees produce serious deformities which render the trees unsightly. Oak, chestnut, maple, locust, and cottonwood are among the trees most likely to suffer from it.

Indication of presence.—Infestation is shown by the wilting of smaller twigs, strings of frass dangling from holes in the bark, the large gallery (fig. 49, *9*), and, when present, the inhabiting worm, which is a large, vivid, reddish-white caterpillar (fig. 49, *7*) up to nearly 3 inches in length, greenish beneath, with scattered, long, fine hairs on the body and with head shining black.

Seasonal history and habits.—It takes this insect about three years to complete its life round, which accounts for the presence of caterpillars in badly infested wood at all seasons of the year. In an oval cell made by the caterpillar at the outer end of the gallery just before completing growth, transformation to the chrysalis (fig. 49, *6*) takes place in May or June.. After about two weeks' life as such the chrysalis wriggles partly out of the hole in the tree (fig. 49, *5*) and the adult moth (fig. 49, *4*) emerges from it. Soon after mating the female begins laying her eggs (fig. 49, *4a*), from 300 to 400 in number, a few in a place and preferably near wounds or scars. The hatching of the eggs and penetration of the resulting caterpillars (fig. 49, *8*) to the heartwood complete the life cycle to the point from which its description was begun.

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[30] *Prionoxystus robiniae* Peck.

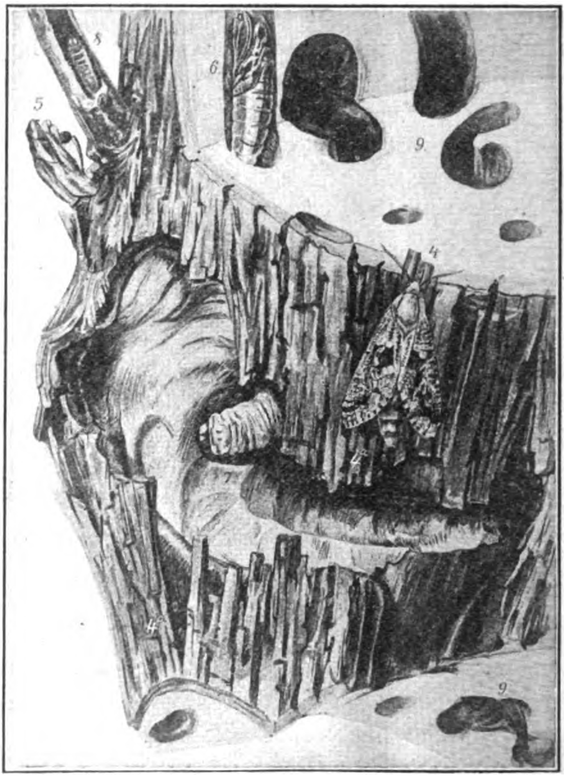

Fig. 49.—Carpenter worm and work: *4*, Female at rest on the bark; *4a*, dark colored eggs deposited loosely in the crevices; *5*, empty pupal case partly sticking out of the burrow; *6*, pupa within its cell; *7*, full grown caterpillar with its head protruding from the burrow; *8*, young caterpillar at work in a small twig; *9*, irregular burrows of full grown caterpillars. (Felt.)

Prevention.—Avoid wounding trees; dress wounds with tar or paint them (p. 14–15) after they are made.

Remedies.—Cut off during the winter and promptly burn all infested wood. Inject carbon disulphid (p. 14) into the wounds and promptly plug them with putty, grafting wax, or similar substance.

MAPLE AND OAK TWIG-PRUNER.[40]

Extent of injury.—While not a menace to the life of trees, the work of the maple and oak twig-pruner, which is often very abundant, tends to destroy the shape and thereby to mar the appearance of trees, besides littering with débris the ground beneath them.

Recognition of work.—During the summer and fall the ground beneath trees is found more or less strewn with small twigs, showing a clean cut at the larger end (fig. 50) with a burrow in the center plugged with wood shavings. Quantities of such twigs may also be hanging from the tree. Freshly fallen twigs, when split in two, disclose the hollowed-out interior and usually at some point within the burrow the whitish grub (fig. 50, *a*) with brown jaws that did the damage.

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[40] *Elaphidion villosum* Fab.

Seasonal history and habits.—The grub above referred to passes the winter in the fallen twig and changes to a pupa early next spring, unless this change has taken place late in the fall, which happens not infrequently. A little later in the spring the pupæ change to adult beetles (fig. 50, *b*), which begin emergence from the wood about June and remain abroad all summer, laying their eggs in July in the smaller twigs of, preferably, oak, but also of maple and other trees. The eggs hatch into grubs, which tunnel and sever the twig.

Remedy.—As the fallen branches usually contain the destructive insect in one form or another, gathering and burning them before emergence is the most logical and the simplest means of controlling the pest.

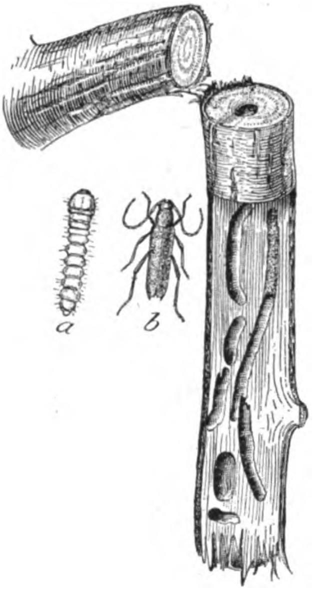

FIG. 50.—The maple and oak twig-pruner: *a*, Larva; *b*, adult; pruned twig and larval mines at right. (Webb.)

TWIG GIRDLERS.[41]

How injurious.—Trees are often found with numerous twigs lying on the ground beneath them or still hanging, dead. The larger ends of such twigs show evidence of having been cut off, and at some place in the burrow running the length of them the architect of the burrow may be found. Among shade and grove trees, hickory, persimmon, elm, poplar, sour gum, basswood, honey locust, dogwood in the East and South, and huisache, mesquite, and acacias in the Southwest, are subject to this injury. This is the work of beetles known as twig-girdlers, and may become so prevalent as to deform trees badly. Young hickory trees are frequently cut off near the ground. The hickory twig-girdler[42] in the East, the pecan twig-girdler[43] in the South, and the huisache girdler[44] in the Southwest, are the insects involved.

Character of work and habits of the insects.—In late summer or early fall these beetles appear and often feed on the thin bark before laying the eggs. The adult female girdles branches of the host tree by cutting a circular incision through the bark and deep into the wood. The twigs so girdled vary from ¼ to 1½ inches in diameter. In these twigs the eggs are deposited in a small scar gnawed through the bark. These branches soon die and most of them fall to the ground. Until the middle of the following summer the larvae feed in the wood, loosely filling the mine with frass, though much of it may be expelled. The pupal cell is firmly walled with fibrous frass. One year is required to complete the development, though in more northern localities many of the larvae feed through the second year before pupating. A high mortality occurs in the larva stage, due to too many borers in the same twig or excessive drying of the branches.

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[41] *Oncideres* spp.

[42] *Oncideres cingulata* Say.

[43] *O. texana* Horn.

[44] *O. putator* Thom.

Remedy.—Gather and burn twigs as fast as they fall.

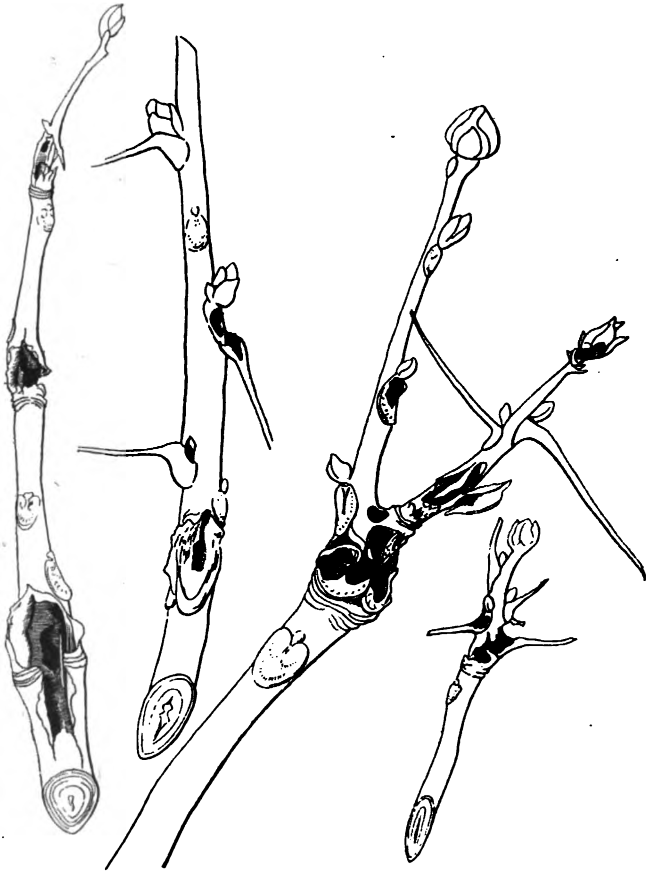

FIG. 51.—Injury by the hickory barkbeetle to the twigs, buds, and base of leaves. (Hopkins.)

HICKORY BARKBEETLE.[45]

How destructive.—For years the number of dead and dying hickory trees throughout this country has been increasing. In many instances the death of these trees has been traced to the work of the hickory barkbeetle. This beetle, then, constitutes a serious enemy of our hickory trees, which, unless prompt steps are taken, are in danger of being seriously depleted.

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[45] *Scolytus quadrispinosus* Say,

Evidence of infestation.—The presence and work of the hickory barkbeetle are indicated in several ways: (1) Bases of twigs, buds, and fallen hickory leaves in the spring show signs of having been eaten by insects (fig. 51); (2) clear-cut, round holes occur in the bark; (3) in August and September the foliage of hickory is faded and dying; (4) the inner bark of hickory trees and the wood surface beneath it are engraved with peculiar centipede-shaped designs (fig. 52), consisting of a broader, central, straight, upright gallery with narrower burrows radiating like centipede legs from either side of it.

History of seasonal activity.—About the time the pollen is falling from the tassels of healthy hickories the beetles mate and each pair starts the excavation of an upright gallery. In niches along the sides of these, eggs are laid which hatch into the grubs that tunnel out the "centipede legs." Until the larvæ are about half grown they feed in the inner layers of bark; later they tunnel into the middle and outer layers of it and pass the winter there. In the following spring they change to pupæ and then to adults, which emerge soon thereafter, thus completing the life cycle in one year. Retarded development of some individuals and accelerated development of others often complicate the situation so that most often all stages of the insect may be found in the same tree at the same time. Each barkbeetle brood gallery cuts that much of the sap flow between root and top, and when these galleries connect up completely around the trunk the tree is girdled and doomed to inevitable death.

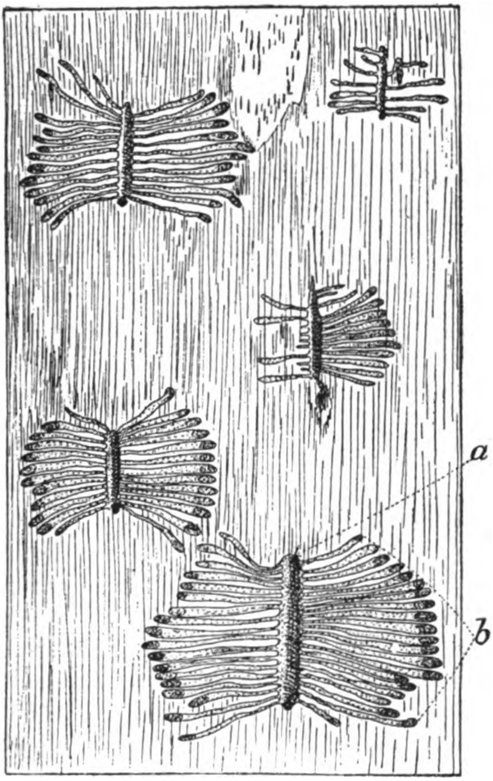

Fig. 52.—Work of the hickory barkbeetle on surface of wood beneath bark. *a*, Primary or egg gallery; *b*, larval mines. (Hopkins.)

Natural checks.—Like all native insects, the hickory barkbeetle is subject to attack in the mature and immature stages by a variety of parasitic and predatory insect and other enemies. By means of the sap flow a vigorous hickory tree is also capable of stubbornly resisting attack. The attack can not be successful, therefore, unless the vitality of the tree is low at the time of attack or unless the beetles are sufficiently numerous to overwhelm a healthy tree. An abundance of sickly, dying, or felled hickory trees in the near vicinity provides favorable conditions for the production of an excess of beetles.

Control.—The evident means of checking the ravages of this pest is to keep the beetles down below a number sufficient to attack vigorous trees successfully. This can be accomplished (1) by putting into practice the very important principle of forestry of prompt, systematic removal from the area and disposal of all hickory trees which show signs of decline, and (2) by cutting and utilizing, for firewood or otherwise, the badly infested trees in the area.

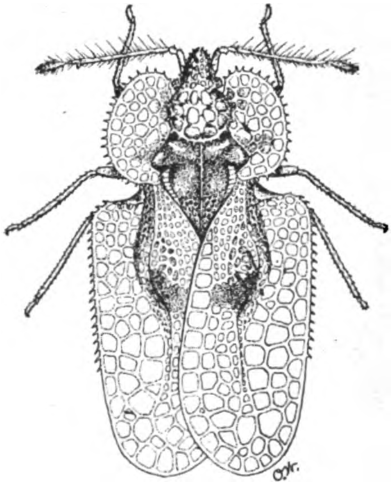

FIG. 53.—Sycamore lace-bug: Adult, greatly enlarged. (Wade.)

SAP-SUCKING INSECTS.

GENERAL.

The feeding of sap-sucking insects on deciduous shade trees is not manifested by visible holes in leaf or bark, but usually by discolored or wilting foliage and generally by the sickly and often black, dirty appearance of the trees. As these insects do not feed on plant tissue but on plant sap, which they secure from the inner tissues by thrusting their beaks through the outer layers, they can not be destroyed by poisoning the foliage of the trees on which they live but must be hit directly by substances which kill on coming in contact with their bodies and which, therefore, are known as contact insecticides.

SYCAMORE LACE-BUG.[44]

How injurious.—By no means can the sycamore lace-bug be called a tree-killing insect, but great numbers of it not only discolor the foliage of the sycamore, its only host tree, but also cause premature falling of the leaves, thus rendering the tree unsightly and littering the ground beneath it. It may be found on sycamore, especially *Platanus occidentalis*, wherever it grows in the United States.

How recognized.—The sycamore leaves are off color in irregular spots or entirely and the underside is inhabited by colonies of queer, rather slow-moving bugs with prettily marked, lace-like horizontal wings (fig. 53), or their offspring with larger or smaller wing pads.

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[44] *Corythuca ciliata* Say.

Habits.—The winter is passed in the adult stage hidden in crevices on the bark of the host tree. As growth starts in the spring the over-wintered individuals move over to the foliage and, after feeding for a week or two and mating, the females lay groups of eggs on the underside of the leaf. These hatch in about two weeks into tiny bugs, which differ from the adults only in lacking wings, and promptly begin feeding. They cast their skin or molt as they grow, doing so five times before maturity is reached. Two or more generations a year are produced, depending on the length and condition of the season, and varying therefore with the latitude and climate of the locality.

Remedy.—When the lace-bug is excessively abundant and other conditions permit, it has been found possible to achieve satisfactory control by spraying the insects with soap solution (p. 14).

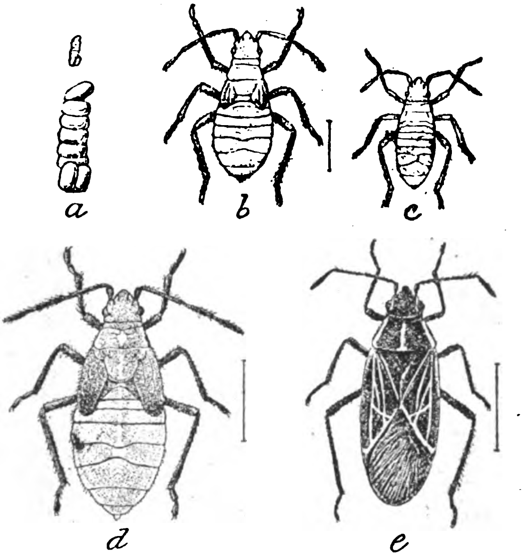

FIG. 54.—The boxelder plant-bug: *a*, Eggs enlarged, natural size above; *b*, *c*, *d*, different stages of immature bugs; *e*, adult. All enlarged; natural sizes indicated by hair lines. (*a–d*, Marlatt; *e*, Howard.)

BOXELDER PLANT-BUG.[47]

How injurious.—Although it feeds on plants only, and primarily on boxelder, this bug (fig. 54, *e*) is known mainly as a fall house pest owing to the fact that, if the infested tree is near enough, masses of the bugs in search of winter quarters are apt to invade dwellings and become a general nuisance there, besides alarming the unwitting householders. It first came to notice some 40 years ago in the far West, but has since spread pretty generally over the States west of the Mississippi River, and has recently been reported in States east of that river.

How recognized.—In late summer large numbers of bright red, wingless or red bordered, darker winged bugs may be seen sucking the sap from the leaves and tender growth of boxelder or, in the fall, masses of them wandering up and down the trunk of the tree and crawling up brick walls and into houses, cellars, and all sorts of cracks and crevices in search of hibernation quarters.

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[47] *Leptocoris trivittatus* Say.

Habits.—The adults emerge from hibernation about the time box-elder buds open and lay their eggs (fig. 54, *a*), usually in crevices of the bark of this favorite host tree. The hatching young migrate to the foliage in great hordes, traveling up and down the trunk. After several molts (fig. 54, *b*, *c*, *d*) maturity is reached and by fall great streams of the bugs start on the march for winter shelter.

Remedies.—Spray trees as soon as the insects appear with soap solution (p. 14) or kerosene emulsion (p. 12–13). In the fall great masses of them can be destroyed by pouring hot water or kerosene on them or by sweeping them into a vessel containing kerosene.

SCALE INSECTS IN GENERAL.

Appearance and habits.—Scale insects are so called because of the scale that covers or constitutes the back of most of them. This covering may be horny, leathery, waxy, cottony, or mealy, and just as various in size, shape, and color. There are many species of scale insects; and, according to the consistency of their covering, they are roughly divided into *armored scales*, *soft* (leathery) *scales*, *cottony scales*, *mealybugs*, etc. Except for a few days after hatching, when they are naked, these insects are nearly always covered by the scale characteristic of the species to which they belong. The number of generations annually, date of hatching, and other life-history habits vary with the species, season, and location. They are all plant feeders, some confining themselves to a single species of plant, while others occur on a great variety of plants. They occur on roots, main stems, branches, and twigs; some of them occur also on the leaves and fruit in summer. They feed on sap, which, by means of their slender, flexible, needlelike beaks, they suck up from within the plant tissues. They are, therefore, classified as sucking insects. Some of them produce more or less honeydew, which attracts ants, bees, wasps, etc., which eat it but do not harm the plants. Certain fungi growing on honeydew frequently give the affected plants a sooty appearance.

Natural control.—Like other insects, most scale insects are usually kept in check by a variety of natural agencies, especially parasitic and predacious insects. Under such conditions they do no permanent serious harm and require no remedial treatment. Quite often, however, some species become so numerous as to be very injurious, and make early treatment imperative if the life of the affected plant is to be saved or its value kept unimpaired.

Remedies.—Winter spraying with a contact insecticide (p. 11–14), done when the buds are dormant, is preferable for scale insects because (1) there is then no delicate foliage to injure and none to conceal the insects or to use up the spray; (2) dead and superfluous portions of the plant may and should then be removed, still further reducing the area to be sprayed and exposing the insects; (3) plants are then dormant and can withstand stronger sprays without injury. Summer spraying, when imperative, is most effectively done when the young are at the height of hatching, i. e., crawling about in numbers.

OYSTER-SHELL SCALE.[48]

How injurious.—The oyster-shell scale lives and feeds on a great variety of shade trees, especially poplar, maple, birch, beech, and willow, besides hardy shrubs and certain fruit trees, all over this country, and though it occasionally kills an entire grown tree, it generally retards and stunts the infested growth and frequently causes the death of twigs and branches.

How recognized.—The bark of an infested branch is found more or less densely crusted with brown or grayish, rather long, somewhat bent scales (fig. 55), wider at one end than the other, and sloughing off more or less readily.

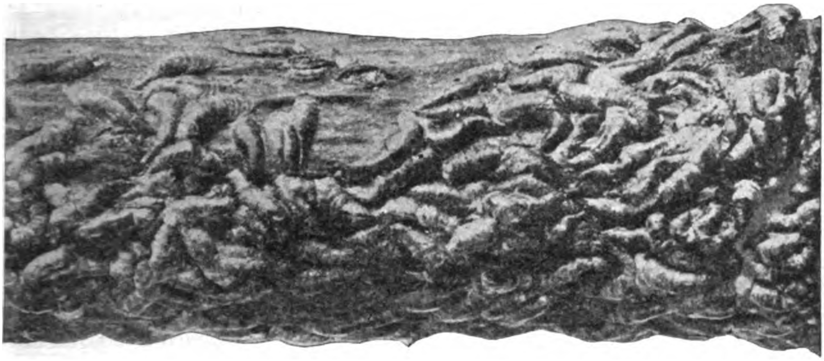

Fig. 55.—Oyster-shell scale on poplar. Much enlarged. (Quaintance and Sasscer.)

Habits and seasonal history.—Shortly after the apple blossoms fall the eggs of the oyster-shell scale, which overwinter beneath the female scale, hatch into minute, licelike insects which crawl about for three or four days, and after inserting the threadlike beak, which serves as an anchor as well as a food conduit, into the host, settle permanently on the bark. Thereafter the female never leaves the scale started by it when young, but ultimately lays its eggs and dies there.

Control.—Here and there an infestation by these scale-bugs is checked by minute, wasplike, parasitic insects that kill them. In most cases, however, spraying with lime-sulphur (p. 11–12) or a miscible oil (p. 12) must be resorted to for a prompt, effective remedy. The necessary preliminary work in preparation for spraying is indicated on pages 15–16.

SAN JOSE SCALE.[49]

How injurious.—For a series of years at the close of the last century the San Jose scale was the most dreaded insect pest of the horticulturist, for not only was it found exceedingly destructive, but few woody plants seemed immune to it. Since then time and intensive study have developed both insect enemies and remedial measures which have effectively curbed its inroads. Nevertheless it is still a serious pest at times here and there, limbs and whole trees being killed by it.

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[48] *Lepidosaphes ulmi* L.

[49] *Aspidiotus perniciosus* Comst.

How recognized.—Ailing trees show the smooth bark roughened and covered with scurf (fig. 56, *a–c*) beneath which pouchlike, yellow insects (fig. 56, *e*) may be observed. The live wood under such bark is tinged with bright red and circles of the same color surround these insects on green growth, leaves, and, in the case of orchard trees, the fruit.

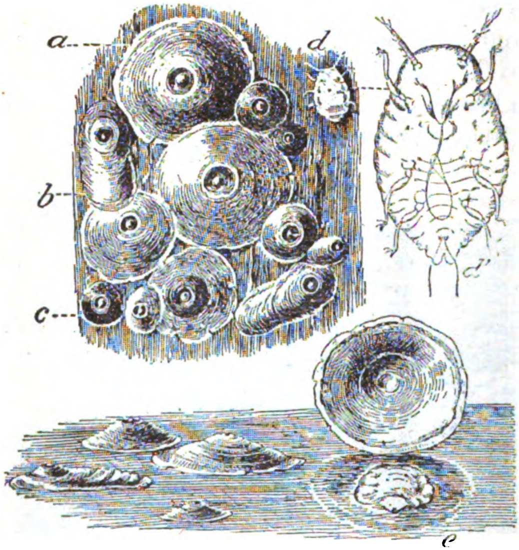

FIG. 56.—San Jose scale: *a*, Adult female scale: *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same highly magnified; *e*, scale removed showing body of female beneath. All much enlarged. (Quaintance.)

Habits.—Attached to the bark this scale insect hibernates in immature stages, resuming feeding and growth with the advent of spring. Maturity is reached and young (fig. 56, *d*, *d'*) are hatching in Washington about the middle of June. After crawling about for a day or two the tiny yellow louse settles down to feed and build the scale. From three to five generations are produced annually, varying with the latitude and climatic conditions.

Remedies.—The San Jose scale readily yields to treatment with miscible oils (p. 12) or with lime-sulphur (p. 11, 12) where their application is practicable. Even fish-oil soap solutions (p. 14) or kerosene emulsion (p. 12–13) give satisfactory results. In heavy infestations two treatments should initiate the work, one in the fall as soon as the leaves fall and the other in the spring just before the buds swell.

GLOOMY SCALE.[60]

How injurious.—The gloomy scale is a special enemy of soft-maple trees, which it often cripples or kills, though other maples may be infested by it. It is especially abundant in the South where it is eliminating the soft maple as a shade tree.

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[60] *Chrysomphalus tenebricosus* Comst.

How recognized.—In appearance it is not unlike the San Jose scale (fig. 56) and the effect produced by it is much the same, except that the red color is absent from the area it infests and the scale is larger and coarser. Also white rings, places from which the scales have peeled off, are a characteristic appearance on old infested surfaces.

Habits.—In its habits this scale is very much like the San Jose scale, except that apparently only one generation is produced in Washington, D. C., and proportionately more farther south. It is a prolific breeder, however, and can incrust trees with its scales in a comparatively short time.

Remedy.—Winter applications of miscible-oil solution (p. 12) will keep it in check.

OBSCURE SCALE.[51]

How injurious.—Oak is the favorite and only host of the obscure scale, and young trees and branches may suffer severely from it or even be killed. This is particularly true of the southern half of the country.

How recognized.—This insect looks much like the San Jose scale. In addition, large whitish rings or circles, which are spots from which the scales have been rubbed off, are an evidence of infestation with this scale. The reddish discoloration characteristic of the San Jose scale is absent and the scale is even coarser than the gloomy scale.

Habits.—Very much like the preceding.

Remedy.—Winter applications of miscible-oil solution (p. 12).

PUBESCENT OAK KERMES.[52]

How injurious.—The pubescent oak Kermes can by no means be considered a tree-killing insect, although twigs here and there may be killed by it. The growth of badly infested trees, however, is severely checked, the tender growth particularly. This scale insect occurs on oaks only; white oak (*Quercus alba*) suffers most from it in the vicinity of Washington, D. C.; burr oak in Ohio and Indiana; and red, chestnut, and chinquapin oaks are other species on which it has been collected.

How recognized.—During the growing season leaves and green, soft wood are found crumpled up, and motionless, hairy, plump bodies resembling the background in color are attached to them. When mature, the insects become much more rounded and chestnut brown in color. Occasionally small, feltlike, white sacks may be found on the wood of branches. These are the male cocoons. Toward the end of the season leaves begin to die and clumps of them remain attached to the tree through most of the winter. During the winter masses of tiny, reddish, licelike insects may be found in cracks of the branches and twigs.

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[51] ***Chrysomphalus obscurus*** Comst.

[52] ***Kermes pubescens*** Bogue.

Habits.—The overwintering young desert their winter quarters about the time buds on the white oak begin to open and migrate to the new growth, where they settle and, inserting their beaks, begin to feed, usually on the midribs of leaves and the soft wood. Wherever one of them settles growth ceases, while the surrounding tissue, of the leaf blade, for instance, continues growing, thus producing the sagging effect. At maturity the body of the female becomes filled with eggs, which, in Washington, D. C., hatch early in July, the "lice" coming from them infesting further the year's growth. Two generations are produced during the year, the offspring of the second hatching late in the fall and migrating to the bark for hibernation.

Remedy.—Experiments made by the writer on several groups of large oak trees have shown that a water solution of miscible oil, 1–15, thoroughly applied at the time the buds begin to swell on the white oak in the spring, kills 85 to 90 per cent of the young insects without hurting the tree in any way. In the given case a high-power sprayer with a solid-stream nozzle was used. The cost of the spraying material averaged about 50 cents a tree. The labor in this particular instance was abundant and free so that no estimate of the cost could well be made. An average of 15 minutes was consumed by the crew to a tree, including transportation over the grounds and time required to fill the tank. For further details on this subject see pages 12 and 22 to 30.

TULIP-TREE SOFT SCALE.[88]

How injurious.—Branches of tulip trees may be so crowded with the tulip-tree soft scale that they sicken and die, greatly disfiguring the tree.

How recognized.—Sickly, blackened branches are found thickly beset on the underside with vivid gray to brown, prominently raised scales about one-fourth inch long and a little narrower. Toward fall the young may be observed crawling about and settling on the bark.

Habits.—The young pass the winter on the bark where, the following spring and summer, they feed and grow, producing young again toward fall, thus making only one generation a year in the latitude of Washington, D. C.

Remedy.—Miscible-oil solution (p. 12) has been found to be an effective remedy for this insect.

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[88] *Toumeyella liriodendri* Gmel.

MAGNOLIA SOFT SCALE.[54]

The magnolia soft scale, as its name indicates, occurs primarily on magnolias, although occasionally on tulip trees. Its appearance, effects, and habits are similar to those of the species infesting the tulip and so also are the measures for its control.

TERRAPIN SCALE.[55]

How injurious.—Maple, especially sugar maple, and sycamore and poplar, among shade trees, are particularly subject to infestation by the terrapin scale, which occurs in several States west of the Mississippi River, and in all of those east of it. It is largely a twig scale.

How recognized.—Infested twigs show the drain from which they are suffering by their wilting and dying foliage. The twigs are more or less heavily incrusted with raised reddish scales (fig. 57) about one-sixteenth to one-eighth inch long, about half as much in diameter, and ridged along the edges. Green shoots and the large veins of leaves are beset with young, licelike insects from midsummer on. Honeydew and black sootlike growth occur on and beneath infested twigs.

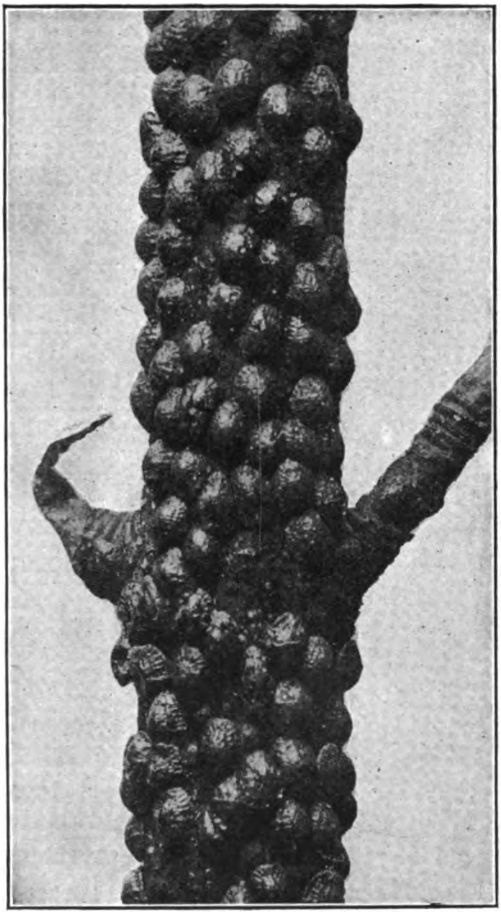

FIG. 57.—Terrapin scale. Adult females on twig of peach. Enlarged about three times. (Sanders.)

Habits.—In a half-grown condition the insect passes the winter on the bark of twigs and branches of its host, resuming feeding and growth as soon as spring starts. Toward the end of May, in the latitude of Washington, D. C., they are full grown and the females are filled with eggs, the young beginning to hatch about the middle of June and continuing to hatch through most of the summer. Evidently only one generation is produced annually in the District of Columbia.

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[54] *Neolecanium cornuparvum* Thro.

[55] *Lecanium nigrofasciatum* Perg.

Remedies.—There is little doubt that kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12), applied in the early spring before the buds have opened, will effectively kill off most of the pest.

COTTONY MAPLE SCALE.[56]

How injurious.—The cottony maple scale attacks a great variety of trees and vines. Its food consists of sap obtained by sucking it from within the plant tissues. Occasionally the insect appears in great numbers and at such times is apt to injure shade and other trees materially.

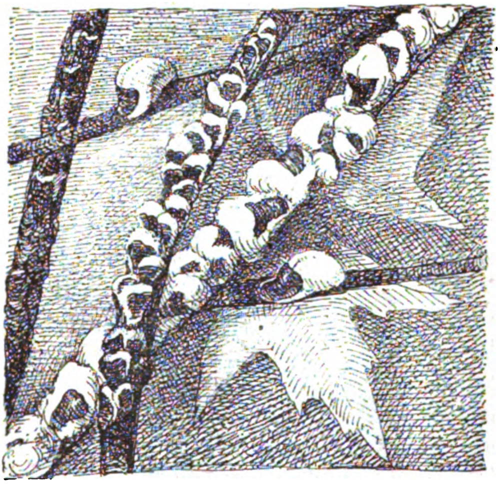

FIG. 58.—Cottony maple scale. Females with cottony ball full of eggs. (Howard.)

Seasonal history and habits.—This scale insect, even when present in great numbers, remains unnoticed until about June, when, at about the latitude of Washington, D. C., it is rendered strikingly conspicuous by the large, white, cottony egg mass which appears at that time at the end of the body of the female insects (fig. 58). The eggs hatch in early summer, though sometimes this hatching extends into August, and the young settle upon the twigs and underside of leaves. In the fall the females migrate to the twigs, where they remain unchanged through the winter, rapidly swelling in the spring and forming the egg mass in early summer. Thus only one generation is produced annually.

Remedies.—Remedies are rarely necessary. Where occasion arises for their use, a spray of dilute (summer strength) kerosene emulsion (p. 12–13) during the hatching of the eggs (June and July) is certain to prove effective.

EUROPEAN ELM SCALE.[57]

History and damage.—The European elm scale, an immigrant from Europe in about 1884, lives on the elm and may occur wherever this tree is grown in the United States. As a rule it does not kill the trees, but it is often so very injurious, especially to young stock, that, together with the injury caused by the elm leaf-beetle, another importation from Europe, attack by bark-borers, etc., is induced and the trees do not recover.

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[56] *Pulvinaria vitis* L.

[57] *Gossyparia spuria* Modeer.

How it lives and looks.—This scale spends the winter in crevices of the bark on the trunk and larger branches as brown immature males and females embedded in white cottony matter (fig. 59). On the appearance of warm weather, in May at Washington, D. C., these forms begin to move about, molt, and mate, after which the females attach themselves permanently on limbs and trunk. The young—clear, lemon-yellow, lice-like insects—issue during June and July, settling temporarily on leaves alone or on leaves and twigs, depending on the smoothness of the latter. In August they return to the larger branches and trunk to settle for the winter, thus completing in Washington the seasonal life cycle.

Remedies.—In the case of shade trees and nursery stock the best means of killing this insect is to spray infested trees during the dormant season with a water solution of miscible oil (p. 12) or kerosene emulsion (p. 12–13). Spraying with summer strengths of these preparations while the young are hatching is the next best means of control. Other means are available, such as water applied with a hose under high pressure, but none of them is as satisfactory as spraying with the solutions mentioned.

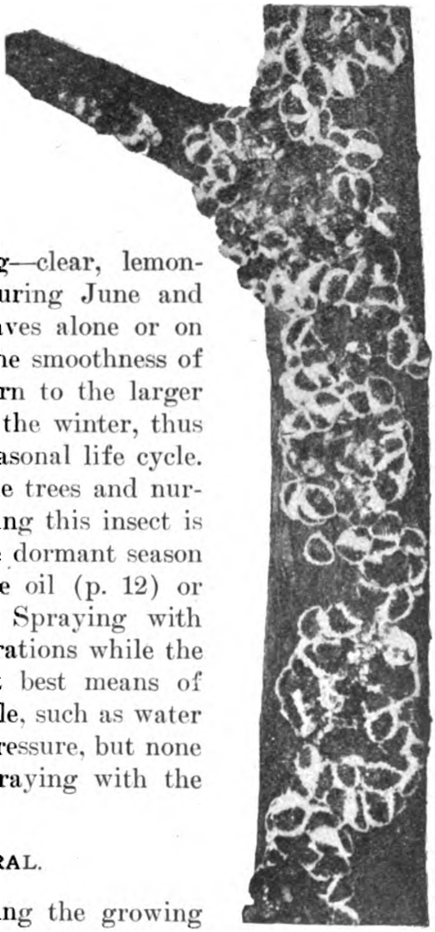

FIG. 59.—European elm scale: Mature females. (Photograph by Sanders.)

APHIDS IN GENERAL.

Evidence of infestation.—During the growing season aphids or plant-lice occur in winged and wingless form in greater or less numbers on branches, twigs, and leaves. They feed on the sap, which they suck up from within the tissues by means of their pointed beaks, hence are classed as sucking insects. Under favorable conditions aphids suddenly appear in great numbers, particularly in the spring. Their presence is indicated by an abundance of sticky "honeydew" on and under the infested plants, by the presence of ants which feed on the honeydew but do not harm the plant, and by the curling and the abnormal falling of the leaves. When this honeydew is very copious, the black film which forms upon it gives the leaves and other portions of the plant a dirty appearance and clogs their breathing pores. Many aphids also produce various growths, called galls, on the tree parts they inhabit.

Control.—Notwithstanding their great numbers, aphids are usually incapable of doing permanent harm to an otherwise vigorous tree. They are never excessively abundant for long periods, being decimated by their numerous insect enemies, and a sharp change in the weather to hot and dry makes their disappearance as sudden as their appearance. Hence treatment, which involves labor and expense and requires an adequate spraying equipment, is in most cases safely dispensed with. When conditions warrant, however, it is possible and not difficult to check aphid injury artificially, as described under the several species. The strength of the solution used should be in proportion to the resistance of the plant to be sprayed; that is to say, the more delicate the plant the weaker the solution. Thoroughness and early application, before the leaves begin to curl, is indispensable to success. Often a forceful stream of water out of a hose directed against the aphids will dislodge and destroy them. Cooperation with neighbors in the purchase and operation of equipment, or in the employment of reliable and competent persons who make a specialty of the work, is desirable where feasible.

NORWAY MAPLE APHIS.[56]

How injurious.—This aphis frequently occurs in large colonies during much of the summer on the underside of Norway maple leaves, which are evidently its favored food. It is a copious producer of honeydew, which accumulates on the leaves and the pavement beneath them. Many of the leaves either develop brown blotches or fall off later, littering the ground and temporarily disfiguring the tree, besides seriously checking growth generally.

How recognized.—The leaves are off color, with honeydew, a sticky sweetish liquid, on them and on the ground below them, and many, mostly wingless, yellowish green, brown marked, licelike insects of various sizes with reddish eyes and long hairy antennæ are found on the underside of the leaves.

Habits.—Our knowledge of the habits of this insect, beyond what has been indicated above, is limited. Fortunately, what is known helps considerably in controlling the insect.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) mixed with soap and diluted in the usual manner will prove quite effective, and as little time as possible should be lost between the discovery of the insect and the application of the remedy. The spray solution should be directed especially at the underside of the leaves.

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[56] *Periphyllus lyropictus* Kess.

BOXELDER APHIS.[59]

How injurious.—This is an insect of the Middle West where the boxelder is its sole host. Its feeding stunts the young leaves, and its honeydew, together with dust and sooty fungus, soils the tree so that it looks most unattractive.

How recognized.—Numerous tiny, pale green, licelike insects are noted on the leaves and tender twigs, and there is a sootlike covering on the leaves and twigs or a sticky liquid on the leaves and on the ground beneath the tree. Drops of this liquid also hit persons beneath infested trees.

Habits.—The winter is passed in the form of eggs laid on boxelder bark. In the spring, as buds begin to push out, the eggs commence hatching and the emerging insects migrate to the new growth, where they forthwith insert their beaks and begin to feed. On reaching maturity they begin to produce living young, each "shelling out" as many as a hundred or more in the course of 20 days or so. Four or five generations thus follow one another in quick succession until about early June, when a generation of a quiescent, inactive form appears, gradually increasing in proportion to the others until August, when only occasional active individuals are to be found. The "dimorphs," as the resting insects are called, do not feed, but rest on the leaves throughout the summer, when the growth seems to take on a new lease on life. Early in September the dimorphs change to the normal, active form and produce another generation or two of living young. All of the individuals hitherto spoken of are females and most of them are wingless. The last generation of the season alone is composed of males and females, and the latter, after mating, deposit their eggs on the bark of twigs and branches, where they overwinter, thus completing the cycle.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) applied at the time new growth starts is a pretty sure and safe remedy.

TULIP-TREE APHIS.[60]

Appearance and injury.—The sole injury of the tulip-tree aphis consists in the abnormally heavy dropping of the leaves, but in a yard or on a street the littering of the ground is a serious objection. The falling tulip-tree foliage, on the other hand, usually indicates the presence of this insect in great numbers on the leaves. The insects have the characteristic appearance of aphids, the winged ones being reddish brown with a pale green abdomen, and there are a few pale reddish individuals scattered among them.

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[59] *Periphyllus negundinis* Thos.

[60] *Macrosiphum liriodendri* Mon.

Remedy.—Forty per cent nicotine sulphate (p. 13) applied as soon as the insects are observed will control them.

WOOLLY MAPLE AND ALDER APHIS.[61]

How injurious.—While this insect can not be considered a serious enemy of the maple, which is the more important of its two hosts, owners of infested trees are greatly distressed by the masses of white cottony fluff they find covering the leaves of their favorite shade tree in the spring, and are insistent on knowing the nature of it and the remedy.

How recognized.—The abundant, bluish white, cottony fluff on the underside of folded-over maple leaves (fig. 60), in the midst of which, from spring to midsummer, winged or wingless (immature) insects are found, is an indication of the presence of this aphis.

Habits.—The aphids in the white woolly masses which appear on the young maple leaves early in the spring come from eggs that were laid the previous fall in cracks and under loose bark on the trunk of the tree. As they reach maturity and acquire wings they migrate to alder, which may be quite a distance away. This may last until midsummer, when all have abandoned the maple. On the alder the migrants settle on the underside of leaves and produce living young, which move over to the bark of twigs, branches, or stems, and settle, feed, and grow there, several generations succeeding one another. Some of the last generation here produced fly back to the maple in the fall, there producing a generation of males and females, the latter laying the eggs with which the cycle was started. Those on the alder that did not migrate in the fall crawl down to the ground, hiding for the winter on the roots and in the leaves and débris at the bottom of the plant, and not coming out until the sap rises the following spring, whereupon they resume the usual activities of feeding and reproduction.

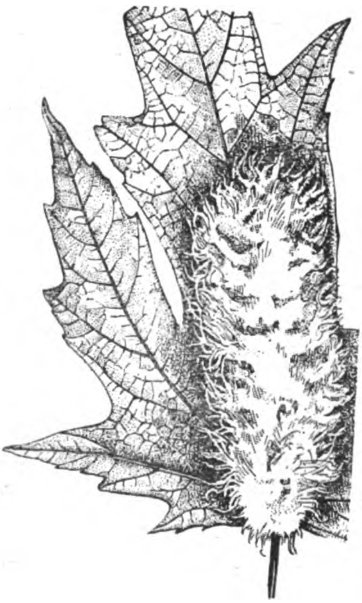

FIG. 60.—Colony of woolly maple and alder aphis on underside of maple leaf. (Pergande.)

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[61] *Prociphilus tessellatus* Fitch.

Remedies.—Since it is not a dangerous insect and treatment of large trees is usually costly, it is not imperative to do anything. Under certain conditions there might be justification for either destroying or treating alders in the neighborhood, and the maple trees, of course, may be treated direct. Both kerosene emulsion (p. 12–13) and 40 per cent nicotine sulphate (p. 13) are efficient agencies for killing this pest.

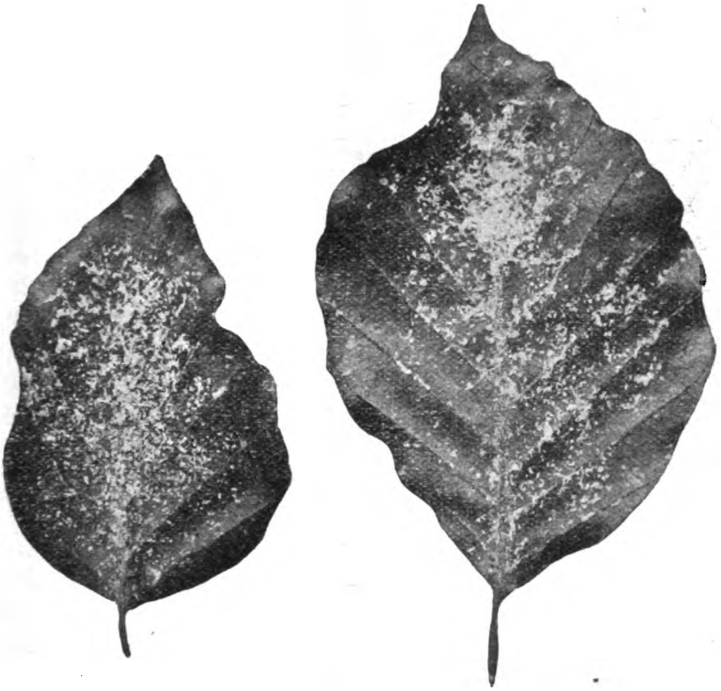

FIG. 61.—Woolly beech aphis on underside of leaves.

BEECH-TREE BLIGHT APHIS[62] AND WOOLLY BEECH APHIS.[63]

How injurious.—While not a menace to the life of trees, the beech-tree blight aphis and woolly beech aphis frequently occur in such abundance as not only to mar the appearance of the trees but also to kill twigs and young trees. The woolly beech aphis (fig. 61) is found to be specially abundant on copper beech leaves.

How recognized.—The masses of bluish-white woolly aphids on the underside of the limbs are the beech-tree blight aphis and those on the underside of the leaves are the woolly beech aphis.

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[62] *Prociphilus imbricator* Fitch.

[63] *Phyllaphis fagi* L.

Habits.—Nothing unusual is known as regards the habits of these insects, so that a reference to any of the other aphids discussed in this bulletin will give an adequate idea on this subject.

Remedies.—Kerosene emulsion (p. 12–13) or 40 per cent nicotine sulphate (p. 13), applied when the aphids are observed, will give necessary relief.

WOOLLY ELM BARK APHIS.[64]

How injurious.—The vitality of trees is not seriously affected by the woolly elm bark aphis but the knotting and gnarling of twigs and trunks (fig. 62) of young elm trees disfigure them. The white elm appears to be its favorite host tree.

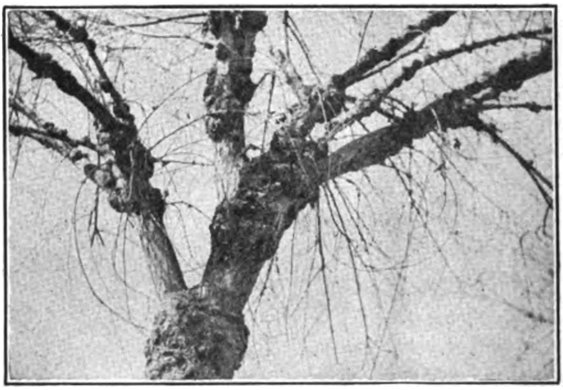

FIG. 62.—Work of woolly elm bark aphis on large elms at Albuquerque, N. Mex. (Photograph by Whitesides, Dec. 13, 1919.)

How recognized.—When this insect is present and at work the trunk and branches show roughened knots with clusters of a white, woolly substance and licelike insects during the spring and summer.

Habits and remedies.—This insect spends its entire life on the elm bark so that treatment on this tree will effectively check its injurious activity. There should be no difficulty in controlling it with 40 per cent nicotine sulphate (p. 13), kerosene emulsion (p. 12–13), or a 5 to 7 per cent solution of a standard miscible oil (p. 12) applied to the bark, the latter in winter.

GALL-MAKING INSECTS AND MITES.

GENERAL.

Leaves and branches of many kinds of trees, particularly oak, maple, hickory, and hackberry, are subject to a great variety of peculiar growths called galls, most of which are made by insects or mites and which may become so numerous at times as to appear alarming. They vary much in shape, size, color, and structure, each being so characteristic of the kind of insect that makes and inhabits it as to afford a reliable guide to the specific identity of the architect in very many cases.

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[64] *Eriosoma rileyi* Thos.

Rarely is a tree harmed by these galls sufficiently to menace its life or even good health. Likewise are they seldom numerous many years in succession, but while they last they do mar the appearance of otherwise healthy and beautiful trees, and their spectacular aspect tends to alarm the less informed tree owners and wardens.

Because of their evanescence and comparative harmlessness, treatment for gall insects is rarely imperative. Another deterrent factor in the undertaking of control measures against this sort of injury is the necessity of rather expensive spraying machinery for the work in many cases, and the cost of purchase or hire of this, as well as of its operation, added to the cost of the requisite insecticides, is apt to be rather excessive. It can only be justified where cost is no consideration, and even then, where the injury is not likely to receive general treatment in a neighborhood, the results of the operation are likely to be unsatisfactory on account of reinfestation from untreated near-by trees.

LEAF-STEM AND OTHER POPLAR GALL INSECTS.[66]

How injurious.—The vitality of trees infested with these aphids is never seriously affected. When the insects are abundant, the galls they make and their feeding frequently cause a heavy dropping of the foliage during the growing season, which, like the misshapen galls produced by some of them, is objectionable because it temporarily disfigures the tree and litters the ground.

How recognized.—The presence of these aphids is shown by heavy premature falling of the leaves, which bear rather prominent swellings on the midrib or leaf stem, the licelike insects lining the insides of them.

Habits.—Of the several species of these aphids known to make galls on poplar leaves, leaf stems, and twigs, the seasonal history of only the species here noted[65] has been worked out. This is somewhat complicated but rather interesting and is, briefly, as follows: By the time the galls are full grown in the fall, winged forms are developed in them and these migrate to the roots of cruciferous plants like cabbage, turnip, etc., where they breed until the following spring. At that time a generation of winged forms is again produced and these fly back to poplar where they give birth to wingless males and females on the bark. After mating the female lays one egg which hatches into the form known as stem mother. The young stem mother appears about the time the leaves begin to develop and migrates to and settles to feed on a stem of a leaf, which begins to swell and grow around her until she is completely enveloped by the gall. Within this gall she reaches maturity and gives birth to the numerous living lice that we find filling it in midsummer. The characteristic feature of the gall made by this species is that its mouth, which later serves as an outlet for its inhabitants, runs crosswise of the leaf stem. This seasonal history applies to the South where the study was made, and while in the main it doubtless applies also to the North there may be some seasonal differences.

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[66] *Pemphigus populi-transversus* Riley et spp.

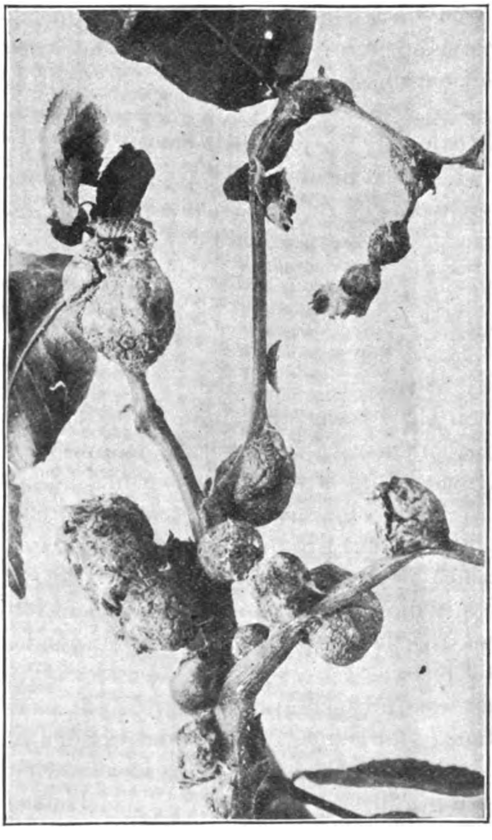

FIG. 63.—The hickory phylloxera (*Phylloxera* sp.): Galls on pecan. (Gill.)

Remedies.—For reasons advanced in connection with other less injurious insects, circumstances are rarely such as to merit or justify control measures. In extreme cases, however, the application of remedial measures might be considered. Depending on conditions, control in such cases may be centered either on cruciferous plants or on poplar trees. In the latter, removing and burning of the infested leaves or dipping them in kerosene to kill the insects would greatly assist in reducing their numbers.

HICKORY GALL-INSECTS.[66]

Evidence of infestation.—In the spring, when the leaves and twigs are forming on the hickory, these are frequently more or less deformed by peculiar tumorlike growths of various shapes and sizes (fig. 63). These are caused either by gall-lice related to the grape phylloxera or by gall midges. When these galls occur in large numbers they disfigure the affected parts and attract attention, but this rarely affects the vitality of the tree materially. Their great variety—30 species of Phylloxeridae and 28 of Itonididae, beside 3 mites (Eriophyidae) are listed under hickory in the latest work on American gall insects—and their general distribution entail heavy infestation at some place in the country each season, with consequent frequent inquiry as to the cause and remedy, so that consideration of them here is made necessary, if for no other reason, to allay the prevailing fear of the consequence of their attack. The similarity of effect and economic relation invite joint consideration of all hickory gall insects.

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[66] Families Phylloxeridae and Itonididae.

Seasonal history and habits.

Phylloxeridae.—From early June of one year to early April of the next, or about 10 months of the year, is passed by these insects in the egg stage located in cracks and crevices, old galls, etc., on the hickory tree, particularly on the upper part of it. Coincident with the bursting of the buds in the spring these eggs begin to hatch, and the larvæ ultimately become the so-called stem mothers. These stem mothers settle on the young twigs, leaf stems, midribs, or forming nuts and each of them starts the formation of a gall with an inner cavity. In about 20 days from the time the gall is started the stem mothers deposit large numbers of eggs from which, in about 20 days, a generation of winged, migrating females develops. By this time the gall begins to open, thus allowing the insects to escape and fly. These migrants in turn lay eggs on the trees, and in about 10 days the young develop into wingless males and females and the mature females lay fertile eggs, which remain on the tree until the following spring, when the complicated life cycle is repeated. Most of the known species of this group infest hickory trees.

Itonididae.—Very little is known about the habits of the hickory gall midges except that, where an egg is laid and a larva hatches from it and develops, the plant tissue produces abnormal growth resulting in a larger or smaller gall, constant in shape and in other respects for each given species.

Artificial control.—Under wild or forest conditions artificial control is entirely impracticable and unnecessary, but in the case of valued shade or nut-producing trees that are regularly infested by the galls, it may be desirable to spray the trees with kerosene emulsion (p. 12–13) at the time the buds are opening in the spring, which should kill the stem-mothers or young maggots, as the case may be, and thus prevent the development of the galls.

HACKBERRY GALL-INSECTS.[67]

How injurious.—The galls made by this group of insects occur only on hackberry trees. In general outer appearance these galls do not differ from the almost equally numerous fly galls that occur on these trees, nor are they more injurious. They occur on the leaves, leaf stems, and twigs and, when very numerous, disfigure the appearance of the foliage, but that is about all the harm they do.

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[67] *Pachypsylla* spp.

How recognized.—Affected parts bear greater or smaller numbers of protuberances or deformities of various more or less uniform shapes and sizes. These are provided with openings and when fresh contain one or more pink tinged, bluish green, immature insects.

Habits.—The insects in the galls attain maturity in the fall, and in this state pass the winter in cracks of the bark on hackberry or among the débris on the ground. At the time buds on these trees begin to swell and open in the spring the insects begin feeding on the tender growth and laying eggs on the leaves. In about three weeks the eggs hatch and the feeding of the ensuing insects causes swelling of the tissue around them until they are almost completely inclosed. Thus one life round is completed in a year.

Remedies.—In the rare instances when remedial measures are warranted, application of a contact insecticide like kerosene emulsion (p. 12–13) or water-soluble oil (p. 13), at the time the young appear on the leaves in the spring and before the galls are entirely closed. should give considerable relief.

OAK GALL-INSECTS.[66]

How injurious.—Over 400 species of gall-making insects are known to affect oaks, and great is the variety of these galls in shape, size, and structure, all parts of the tree from the root up, including buds, flowers, and fruits, being subject to these deformities. A tree or part of it, particularly its foliage, may be literally covered with the galls of one or more species or may be completely changed by them, and, while the aspect is not always agreeable, the life or health of the tree is never menaced thereby.

How recognized.—Either the size, the shape, the color, or the number of these abnormal growths leads to their ready detection, especially on the foliage. The specific identity of the particular architect, however, can be determined only by the special student of this group of insects. To tree wardens this identity is of secondary consideration, since the injury is so rarely of more than secondary importance.

Habits.—No general outline of the habits applying to all these gall builders can be given. Not all of them are known, and there are too many even of those known for enumeration in this bulletin. Roughly, however, the habits are as follows:

The gall wasps.—In some of the gall wasps a life cycle has been found made up of several generations, only one of which consists of the two sexes. The females of the original generation usually lay their eggs between March and May, and frequently during the period from November to January, while those of the paired generation lay their eggs between June and August. The eggs are laid either on or in the particular portion of the plant they infest, and the developing egg starts and stimulates the growth of the gall around it. The grub which hatches from the egg is footless, creamy or white in color, and feeds, grows, and transforms to the adult four-winged fly in a cell in the gall and then bores its way out into the open.

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[66] Gall wasps (family Cynipidae); gall gnats (family Itonididae).

The gall gnats.—The adult insect is usually a rather small, two-winged gnat, seldom recognized by other than entomologists. In the course of flight the eggs are laid on the surface of the object of attack, which may be leaf, flower, fruit, bud, or stem. Wherever the egg is laid the tissue around it reacts by producing an unusual growth culminating in a closed gall wherein the creamy, greenish, yellowish, or pinkish maggot feeds and may be found while the gall is still green. The pupa is formed within the gall, or else the maggot, upon reaching full growth, drops to the ground and there transforms to the pupa and subsequently to adult fly. There is apparently only one generation a year in most of these flies.

Remedy.—Where some action is imperative—and this can only be true of very highly prized trees after several years of repeated infestation—cutting and burning of gall-laden wood or fallen leaves while the insects are still within the galls is bound to result in considerable benefit if the work is carried out on the infested oaks of a sufficiently extensive area.

RED SPIDERS.[a]

Character and extent of damage.—During a protracted drought the red spider is likely to become very injurious, attacking a great variety of plants. Whole trees, especially seedlings and nursery stock, are apt to have their foliage killed by it.

Evidence of infestation.—Pale brownish spots which may later cover the foliage of the entire plant and a web sometimes so dense as to be plainly visible at a considerable distance appear on the leaves. On examination with a magnifying lens the affected leaves are found to bear numerous, tiny, pearl-like eggs, brownish or reddish little creatures running about, or the glistening empty eggshells and cast skins of the mites.

Seasonal history and habits.—"Red spider" is the name most often applied to two species of web-spinning mites. Mites differ from true insects in having four pairs of legs in the adult stage (fig. 64). They pass the winter as adult females on various wild plants. In the spring they ascend plants and start egg laying at the rate of 5 to 10 eggs a day for a period of 8 to 12 days. During hot, dry weather the eggs hatch, in about 4 days after having been laid, into young mites which commence feeding almost immediately. They reach maturity in 10 to 14 days after hatching, depending on the season and locality. Many generations follow one another in the course of one summer. Usually by the time their presence is discovered they are already very numerous. They live and feed in colonies and their feeding consists in sucking the juices from leaves.

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[a] *Tetranychus telarius* L. and spp.

Remedies.—A stiff stream of water, frequently applied, will rid plants of the red spider in many cases. Individual trees may be sprayed with lime-sulphur (p. 11–12) mixed with soapy water or kerosene emulsion (p. 12, 13). Kerosene emulsion or miscible oil mixed with nicotine sulphate in the usual proportions should also give satisfactory results. Make at least two applications with a 10-day interval between them, the first as soon as the mites appear.

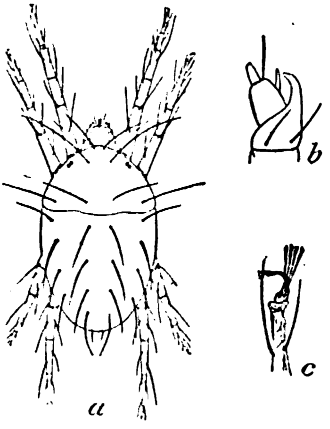

FIG. 64.—Common red spider (*Tetranychus telarius*): *a*, Adult, *b*, palpus; *c*, claws. (Banks.)

GALL-MAKING MITES.[70]

How injurious.—The galls made on shade trees by these microscopic animals are most often located on the leaves or other tender part of the growing plant and, while the affected parts may be badly misshapen or discolored, serious harm to the vitality of vigorous trees is rare.

How recognized.—The mite-made gall is always open and the opening is fringed with hairy growth, or, in fact, the very gall may consist of but a larger or smaller clump of such hairs. In the later stages of development some of these galls assume red and other colors, all invariably turning brown after being deserted by the mites.

Habits.—The mites overwinter hidden under bud scales and probably also bark scales, and start feeding and reproduction early in the spring, in known cases before the buds open. The number of generations produced during the growing season by any given species is not definitely known, but evidently there are several of them. When the food supply on a given spot gives out the mites migrate to another, often covering whole leaves or deforming the buds of entire trees in the course of a season. Their eggs are laid on the surface of the affected area and the feeding is supposed to cause the irritation which produces the abnormal growth. No explanation is yet available for the characteristic gall made by each species of mite, even though produced on the same plant.

Remedies.—Thorough spraying of infested trees during the dormant season with a contact insecticide, like kerosene emulsion (p. 12–13) or miscible-oil solution, should well-nigh exterminate a bad colony.

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[70] Family Eriophyidae.

DECIDUOUS SHADE-TREE INSECTS ARRANGED ACCORDING TO THE MANNER OF ATTACK AND KIND AND PART OF TREE SUBJECT TO IT.

ALDER.

See Maple, p. 98.

ASH.

Mite.

Deformed buds------------------------------------*Ash-bud gall-mite*, p. 94.

Borer.

Wood of trunk especially near base, honeycombed, burrows packed with granular frass------------------------------------*Parandra borer*,[11] p. 61.

BOXELDER.

Sap suckers.

(1) Masses of a reddish bug on tree trunk and branches and a nuisance about dwellings in fall------------------------*Boxelder plant-bug*, p. 75.

(2) Leaf sap-sucking, licelike insects--------------*Boxelder aphis*, p. 85.

BEECH.

Sap suckers.

(1) Masses of bluish-white, woolly aphids on underside of limbs---------- *Beech-tree blight aphis*, p. 87.

(2) Masses of bluish-white, woolly aphids on underside of leaves---- *Woolly beech aphis*, p. 87.

BIRCH.

Borer.

Reddish or rusty brown spots on white bark of trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows in bark and wood; ridges in the bark on the branches which often develop over the burrows; dying tops of the trees-------------------- *Bronze birch borer*, p. 59.

BUTTERNUT.

See Walnut, p. 100.

CATALPA.

Leaf chewer.

Leaves eaten by yellow and black striped caterpillars having a short horn near hind end of body; caterpillar droppings beneath trees------------ *Catalpa sphinx*, p. 33.

CHESTNUT.

See Oak, p. 98–99.

COTTONWOOD.

See poplar, p. 99.

ELM

Leaf chewers.

(1) Leaves show holes in early spring; later, abrasions on underside and holes--*Elm leaf-beetle*, p. 38.

(2) Holes in leaves with spindle-shaped bags near by----*Bagworm*, p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars up to 2 inches long---------------*Spiny elm caterpillar*, p. 48.

(4) Twigs or branches covered with web containing hairy caterpillars. *Fall webworm*, p. 40.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back----*Forest tent caterpillar*, p. 35.

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[11] This borer is to be found in a great variety of species of both deciduous and coniferous trees.

(6) Leaves eaten by green looping caterpillars or measuring worms----
Spring cankerworm, p. 36.

(7) White, frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back--------
White-marked tussock moth, p. 41.

(8) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back------------------------*Large elm sawfly*, p. 51.

Borers.

(1) End leaves turning brown and falling in summer; tops and branches fail to leaf in spring; trunk and branches show patches of dead, easily peeling bark with burrowing, roundheaded grubs beneath it----------
Elm borer, p. 55.

(2) Twigs wilt and break off, bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk------
Leopard moth, p. 68.

(3) Girdled twigs hanging on trees or lying on ground below trees------
Twig girdler, p. 71.

Sap suckers.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail-------------------------------*Oyster-shell scale*, p. 77.

(2) Bark on trunk or branches bearing larger or smaller rough, white, meal-covered knots---------------------*Woolly elm bark aphis*, p. 88.

(3) Branches and trunk, especially at crotches, more or less crowded with stationary brownish insects bordered by cottony white----------
European elm scale, p. 82.

(4) Cockscomblike growth on leaves-----------------*Gall aphids*, p. 88.

GUM, SOUR.

Borer.

Girdled twigs hanging on trees or lying on ground below them-----------
Twig girdler, p. 71.

GUM, SWEET.

Leaf chewer.

Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back---------------*Forest tent caterpillar*, p. 35.

HACKBERRY.

Leaf chewers.

(1) Leaves partly or entirely eaten by spiny, black, red-marked, caterpillars up to 2 inches long-----------------*Spiny elm caterpillar*, p. 48.

(2) Leaves being eaten by green caterpillars with pale spots and lines along back and projections on head and rear-----------------------
Caterpillars of hackberry butterflies, p. 49.

Galls.

On leaves and twigs growths (galls) of various shapes and sizes----------
Hackberry gall insects, p. 91.

HICKORY.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long--------------------------------------*Walnut caterpillar*, p. 46.

Borer.

(1) Leaves eaten at base of stem; tree sickly, bark inside and surface of outer wood with centipede-like engravings--*Hickory barkbeetle*, p. 72.

(2) Girdled twigs hanging on trees or lying on ground below trees------
Twig girdler, p. 71.

Galls.

Abnormal growth on leaves and leaf stems-----------*Gall aphids*, p. 90.

HONEY LOCUST.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back---------- *White-marked tussock moth*, p. 41.

Borer.

Girdled twigs hanging on trees or lying on ground below trees---------- *Twig girdler*, p. 71.

HORSE CHESTNUT.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back------------ *White-marked tussock moth*, p. 41.

Borer.

Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk------------ *Leopard moth*, p. 68.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail--------------------------------------*Oyster-shell scale*, p. 77.

LINDEN.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back-------*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back--------- *White-marked tussock moth*, p. 41.

(4) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back-----------------------------*Large elm sawfly*, p. 51.

Borer.

(1) Toward end of summer tips dead and green bark eaten; large irregular burrows made by slender white grub under the bark and deep in the wood near ground---------------------------------*Linden borer*, p. 57.

(2) Girdled twigs hanging on trees or lying on ground below them------ *Twig girdler*, p. 71.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail----------------------------------*Oyster-shell scale*, p. 77.

LOCUST.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back------*Forest tent caterpillar*, p. 35.

(3) Foliage on tree as if fire scorched; leaves blistered and hollowed out---*Locust leaf-miner*, p. 43.

Borers.

(1) Trunk and branches gnarled, breaking, and showing wet spots and boring dust-----------------------------------*Locust borer*, p. 63.

(2) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath-------------- *Carpenter worm*, p. 69.

MAGNOLIA.

Sap suckers, scale insect.

Wood of branches sickly, blackened, and underside beset with vivid gray or brown, raised, rather large scales---------*Magnolia soft scale*, p. 81

MAPLE.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back--------*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back---------- *White-marked tussock moth*, p. 41.

(4) Leaves eaten by smooth, pale yellowish-green caterpillar, lengthwise striped with dark green and with a pair of black "horns" and black pegs along sides and rear end--*Green-striped maple worm*, p. 44.

Borers.

(1) Foliage on limb wilting and dying and sap with some frass oozing from some point on tree; limbs dead, ridges and dead spots on bark; naked scars on trunk near base of limbs; three-eighths to five-eighths inch oval holes at base of tree--------------*Sugar-maple borer*, p. 53.

(2) Twigs wilt and break off; bark split open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk--------- *Leopard moth*, p. 68.

(3) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath--------------- *Carpenter worm*, p. 69.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh------------------------- *Maple and oak twig-pruner*, p. 70.

Sap suckers, scale insects.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail---------------------------------------*Oyster-shell scale*, p. 77.

(2) On twigs and leaves in summer, white, fluffy cottonlike masses with darker blotch toward one end------------*Cottony maple scale*, p. 82.

(3) Tree ailing, bark of trunk and branches more or less incrusted and roughened by stationary, black, circular scales; also white circles---- *Gloomy scale*, p. 78.

(4) Tree ailing, twigs blackened and more or less thickly incrusted with raised, reddish scales, ridged along edges-------*Terrapin scale*, p. 81.

Sap suckers, aphids.

(1) Abundance of bluish-white wriggling cottony fluff on underside of maple leaves in spring and summer-------------------------------- *Woolly maple and alder aphis*, p. 86.

(2) Leaves discolored and sticky with honeydew and ground beneath trees covered with the same; yellowish green, brown marked, mostly wingless aphids of various sizes with reddish eyes and long hairy antennæ on underside of leaves-----------*Norway maple aphis*, p. 84.

(3) Leaves more or less densely covered with one or more of the following growths: "Pouch" or "nail" galls (mite made); "eye" spots (fly made)-------------------------*Gall insects and mites*, p. 88.

OAK.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery diamond-shaped spots along the back---*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back-------- *White-marked tussock moth*, p. 41.

(4) Leaves eaten by looping caterpillars or measuring worms----------- *Fall cankerworm*, p. 36.

Borers.

(1) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath----------------- *Carpenter worm*, p. 69.

(2) Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk-- *Leopard moth*, p. 68.

(3) Trees sickly, inside of bark densely scored by frass-filled mines running in al directions-------*Two-lined oak and chestnut borer*, p. 61.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh------------------------- *Maple and oak twig-pruner*, p. 70.

Sap suckers, scale insects.

(1) Leaves and tender shoots crumpled up, older leaves and twigs studded with stationary brown, pea-shaped scale insects---------------- *Pubescent oak Kermes*, p. 79.

(2) Tree ailing, smooth bark of trunk and branches more or less incrusted and roughened by stationary black, circular scales; also white circles---*Obscure scale*, p. 79.

Galls.

Swellings of various shapes and dimensions on upper and under side of leaves or on twigs---------------------------------*Oak galls*, p. 92.

PERSIMMON.

Borer.

Girdled twigs hanging on trees, or lying on ground below trees---------- *Twig girdler*, p. 71.

POPLAR.

Leaf chewers.

(1) Leaves with holes bitten part way or entirely through, later entirely consumed by spotted, soft-bodied, short, stoutish grubs and spotted or striped beetles one-half inch long-- *Cottonwood, poplar, and willow leaf-beetles*, p. 50.

(2) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars, up to 2 inches long----------------*Spiny elm caterpillar*. p. 48.

(4) Leaves blistered or eaten by coiled yellowish-white worms with black line along back-------------------------*Large elm sawfly*, p. 51.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back----*Forest tent caterpillar*, p. 35.

(6) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back---------- *White-marked tussock moth*, p. 41.

(7) Twigs or branches covered with web containing hairy caterpillars--- *Fall webworm*, p. 40.

(8) Leaves being eaten by caterpillars with long, soft, drooping, yellow hairs and with five rather long, stiff tufts of black hairs along the back; when at rest, curled up on underside of leaf------------------------ *Cottonwood dagger moth*, p. 47.

Borers.

(1) On trunk at crotches irregular scars from which sap oozes and fibrous borings protrude-----------------------------*Aspen borer*, p. 58.

(2) Dead or dying limbs, swellings and dead patches of bark often cracked open on limbs and trunk; fading foliage; sawdust and oozing sap at points of attack; injured twigs with burrow along middle with white, fleshy, footless grub at some point---------------------------- *Mottled willow and popular borer*, p. 65.

(3) Trees breaking, tops sickly, shredded boring dust in piles on ground beneath trees; borer work under bark close to ground----------------- *Cottonwood borer*, p. 66.

(4) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish white, greenish beneath--------------- *Carpenter worm*, p. 69.

(5) Girdled twigs hanging on trees, or lying on ground below trees------ *Twig girdler*, p. 71.

Sap suckers, scale insects.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail--*Oyster-shell scale*, p. 77.

Sap sucker, gall-maker.

Leaves bearing prominent swelling on stem and dropping prematurely--- *Poplar leaf-stem gall-aphis*, p. 89.

SYCAMORE.

Leaf chewer.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 81.

(2) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back-------- *White-marked tussock moth*, p. 41.

Sap sucker, bug.

Leaves off color in spots or entirely; underside shelters colonies of slow-moving, lacelike bugs and their young--------*Sycamore lace bug*, p. 74.

TULIP TREE.

Sap sucker, aphid.

Leaves discolored, dropping, with numerous aphids on underside, sticky with honeydew-------------------------------- *Tulip-tree aphis*, p. 8[illegible]

Sap sucker, scale insect.

Sickly, blackened branches beset with vivid gray or brown, rather large, high scales----------------------------------*Tulip-tree soft scale*, p. [illegible]

WALNUT.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long---------------------------------------*Walnut caterpillar*, p. [illegible]

WILLOW.

See Poplar, p. 99.

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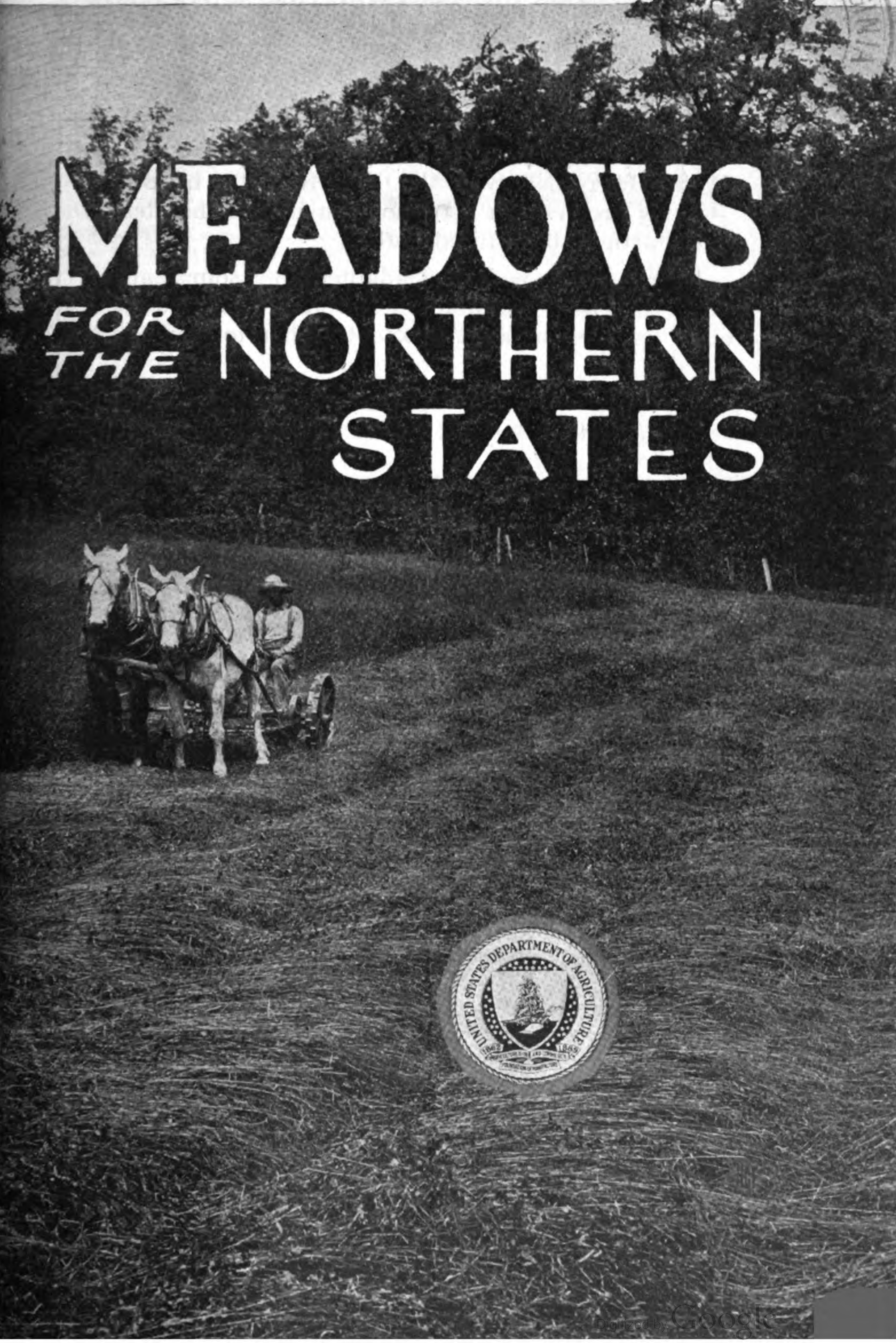
FARMERS' BULLETIN 1170

UNITED STATES DEPARTMENT OF AGRICULTURE

SITY OF VIRGINIA
GENERAL



MEADOWS FOR THE NORTHERN STATES

TIMOTHY AND RED CLOVER form the basis of hay growing on good soils in the northeastern one-fourth of the United States.

Alsike clover is better adapted to "sour" and moist soils than common red clover, and the two are often used on uplands mixed together to insure a stand.

Redtop is the best wet-land grass, but meadow fescue and timothy will thrive under fairly moist conditions.

A good wet-land mixture is redtop, meadow fescue, and alsike clover.

There are no good poor-land hay grasses. Redtop, orchard grass, and tall oat-grass will make a stand on soils of medium productivity, but it requires a rich soil for commercial hay growing.

The best temporary hay plants are the small grains, either alone or in mixture with some legume, such as peas, vetch, or crimson clover, or millets, Sudan grass, and coarse forages, such as corn or sorghum, seeded thickly.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. November, 1920

MEADOWS FOR THE NORTHERN STATES.

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THE AREA of tame-hay plants grown in 1909 in the region covered by this bulletin (fig. 1) aggregated 39,174,918 acres, according to the Bureau of the Census. The total yield that year was 50,594,171 tons. This area represents more than 83 per cent of the tame-hay acreage of the United States. Timothy alone or clover alone (mainly red and alsike clovers) and imothy and clover mixed constituted more than 88 per cent of the acreage of tame hay in this northeastern portion of the country. The ultural methods for imothy and clover re so well understood that they do not require the attention n this bulletin which their importance would seem to warrant.[1] These plants undoubtedly will continue to hold for many years

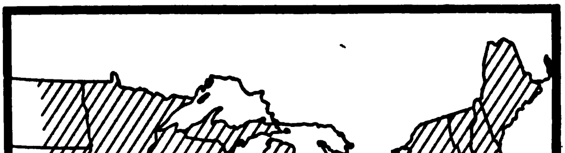

FIG. 1.—Outline map of the eastern United States, showing the region to which this bulletin applies.

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[1] For additional information in regard to the culture of timothy, see Farmers' Bulletin 90, entitled "Timothy."

to come the popularity they now possess. While timothy and clover are the most profitable hay plants for most of this region, there are a number of other plants which, though not so well known, are more desirable for particular purposes or for certain conditions of soil and climate. These are referred to in this bulletin in the discussions of combinations of hay plants for special purposes. Hay plants may be classified as annual, biennial, and perennial, according to whether they live one, two, or more than two years. Millet, sweet clover, and timothy are examples, respectively, of these three classes.

PERMANENT, ROTATION, AND TEMPORARY MEADOWS.

Meadows may be considered as permanent, rotation, and temporary, depending on the length of the period during which they are allowed to grow before tilling the land. Permanent meadows are those that are kept in grass indefinitely and are mowed for hay. There are few such meadows in the northeastern portion of the United States except those on bottom lands and in localities where the production of other crops has become economically unprofitable. Lands that are occasionally subject to overflow often make splendid permanent meadows. In most cases, however, it is more profitable to plow the land every two or three years and reseed. Most hay plants make their maximum yields the first and second years after seeding. After that they tend to deteriorate and the yields are diminished. Alfalfa, orchard grass, redtop, meadow fescue, and alsike clover are some of the best plants for permanent meadows.

Rotation meadows are those that are seeded in regular crop rotations and are usually left for two or three years. The common rotations, such as the well-known 4-year rotation of corn, wheat, and two years of hay and the equally well-known 5-year rotation of corn, oats, wheat, and two years of hay, are applicable to this entire region. The greater part of the market hay is produced by farmers practicing these rotations. Timothy, red clover, perennial rye-grass, and orchard grass are suitable for rotation meadows.

Temporary meadows are those used for hay but one year. They are seeded to some quick-growing crop. Millet, red clover, Sudan grass, Italian rye-grass, and the cereals make good temporary hay plants.

PLANT MIXTURES FOR MEADOWS ON FERTILE WELL-DRAINED SOILS.

There is little difference of opinion as to the plants to be seeded on rich well-drained land. Timothy is seeded alone when the hay is to be sold on the market, and timothy and clover, often mixed with redtop, where part or all of the hay is utilized on the farm. The long period during which these two plants—timothy and red clover—have held their popularity as hay plants in this region precludes the likelihood of their being superseded in the near future by any others. Some of the reasons for the popularity of these plants may be stated briefly: They have good seed habits, especially so in the cases of timothy and redtop, and the seed is obtainable in large quantities; red clover is a deep-rooted legume and has a beneficial effect on succeeding crops; timothy is considered by feeders the best hay for horses; and clover or clover and timothy mixed are excellent for cattle and sheep. They make heavy yields of hay. The comparatively long period during which these plants may be left standing without serious deterioration before cutting, together with the fact that the time of maturity of these plants interferes little with the harvesting of the cereals and other farm work, have much to do with their popularity. The most serious objection to their culture is due to the differences in the time of their maturity. Red clover is ready to cut about two weeks before timothy is mature. Mammoth clover, a variety of the common red clover, is somewhat later in maturing and is often used in place of red clover in mixture with timothy. In practice, the difference in the time of maturity is not such a serious fault as it might seem. Red clover greatly predominates the first year after seeding and should be cut when in full bloom. By the second year much of the clover has died out and the timothy may be allowed to reach the proper stage before cutting. Whether it is best to use redtop in this mixture depends mainly on the purpose for which the hay is grown. Hay buyers will usually discriminate against timothy hay that has an admixture of redtop. Although redtop is not so palatable as timothy, there is not the difference in the feeding values of these two grasses that their market prices would indicate. If the hay is to be consumed on the farm it is probably advisable to include a small proportion of redtop when seeding. The addition of redtop will add somewhat to the total hay produced and will not crowd out the other plants to any great extent.

Owing to the increasing difficulties of getting stands of red clover in the older farming sections many farmers are using mixtures of alsike and red clovers instead of red clover alone in the above mixture. This practice gives an added insurance against the failure of the stand and is to be recommended wherever success with red clover is uncertain. It must be borne in mind, however, that the growth of alsike clover on dry uplands is small.

MIXTURES FOR POORLY DRAINED FERTILE LANDS.

It is impossible to succeed with any of the common tame grasses on lands which are water-logged. An occasional overflow does little damage to the stand of grass unless water remains for several days or there is a large deposit of mud from the water.

There are three good wet-land plants besides timothy which will tolerate considerable moisture.

The best grass for such conditions is redtop. If the land is too wet for redtop there is little use of seeding anything. Reed canary grass (*Phalaris arundinacea*) and wild rice (*Zizania aquatica*) might be used, but the seed of both is expensive. The legume which will do best on moist lands is alsike clover. This makes a good growth and is in every way as desirable for the conditions under which it thrives as red clover is for well-drained soils. Meadow fescue is another grass which does well on moist lands. All the other tame grasses succeed much better on well-drained soils.

The following mixture is suitable for moist meadows, the quantities specified being the rate to seed per acre: Redtop, 8 pounds; alsike clover, 6 pounds; meadow fescue, 14 pounds. In case the lands are not very wet 10 pounds of timothy may be substituted for the meadow fescue. It is customary with lands of this character to keep the fields permanently in grass, and in that case it will be desirable to use both the meadow fescue and timothy at the rate of 10 and 6 pounds, respectively.

MIXTURE FOR THE SOUTHERN BORDER OF THE TIMOTHY BELT.

There are many soils along the southern border of the area under discussion which will give a larger hay crop if seeded to orchard grass, tall oat-grass, and alsike clover than if seeded to the timothy, redtop, and red-clover mixture. These soils are usually poor in organic matter and are inclined to be "sour." Orchard grass, tall oat-grass, and alsike clover all mature at about the same time and nearly two weeks earlier than timothy. This mixture must be cut when the plants first head out or it will make a tough, less palatable hay. This is especially true of orchard grass. If cut early the hay will be relished by all classes of live stock. Common red clover may be substituted for alsike clover on good uplands, but a mixture of the two is more likely to give a stand than either alone under such conditions. For general use the Arlington mixture is recommended: Orchard grass, 14 pounds; tall oat-grass, 12 pounds; alsike clover, 6 pounds per acre.

POOR-LAND HAY PLANTS.

Raising hay on poor land is not satisfactory. It is, however, sometimes necessary to make the attempt. The orchard grass, tall oat-grass, and alsike mixture is perhaps the best for poor clay lands. In some places in the Middle West sweet clover is giving good results under unpromising soil conditions. There are no perennial hay plants that will produce well on poor sandy soils. Tall oat-grass and redtop will usually catch, but will scarcely produce a hay crop. Some temporary crop, such as rye or oats and peas, should be used under such conditions. Early sorghums and cowpeas are often used along the Atlantic coast and will make a very good hay for home use. They are, however, difficult to cure. No one should make a practice of growing hay for market on poor land.

TEMPORARY HAY PLANTS.

There are a number of quick-growing plants which make hay of fair quality. Among these plants are all of the small grains. When the price of grain is low enough to justify the practice, oats, wheat, barley, and rye may be made into hay. Rye should be cut when it first heads or it may become too tough for stock to relish. A delay of a few days makes a marked difference in this respect. The other cereals may be allowed to stand a little longer, but they should be cut by the time the seed is in the milk stage.

In the Northern States a combination of oats and Canada field peas makes a very good hay crop. It should be seeded as soon as the soil can be worked in the spring. Varying mixtures of these two plants are used. A common one is made up of 1½ bushels of oats and 1 bushel of peas to the acre. The two kinds of seed may be mixed together and seeded with a grain drill. A more evenly mixed stand, however, will be obtained if they are seeded separately. Some broadcast the peas before plowing and turn them under with a turning plow. The oats are then seeded in the usual manner. Where this method is practiced, the plowing should be not more than 5 or 6 inches deep. Some put the peas in first, running the drill so as to put the seed at least 4 inches below the surface, and then broadcast the oats about a week later and harrow them in. Heavy rains after seeding the peas may prevent the successful operation of this method.

Millet is often used for a temporary hay crop. The fact that it may be seeded after a failure of corn or some other spring-seeded crop or after it is certain that the regular hay crop will be short makes millet of great value. The common or Hungarian variety should be used in the northern part of the timothy belt and the German in the southern. Japan millet does well in New England. Millet may be seeded at any time after corn planting up to July. The last seeding should allow at least 60 to 70 days before it is time for a killing frost. The rate of seeding for millet in this region is usually from 25 to 30 pounds to the acre.

A combination of plants which has given excellent results in eastern Maryland and Virginia is winter oats, hairy vetch, and the white-blooming variety of crimson clover. This white-blooming variety is about two weeks later in maturing than the common crimson clover and fits in better in this mixture. The vetch should be inoculated if the land has not grown vetch previously. A good mixture of these seeds will be—

	Per acre.
Oats	1 bushel.
Hairy vetch	30 pounds.
White-blooming crimson clover	10 pounds.

Sudan grass alone or in combination with an early variety of cowpeas or soy beans makes an excellent temporary hay mixture for the country south of Pennsylvania.

TIME AND METHOD OF SEEDING.

The customary method of seeding grasses and clover with a small grain has some advantages and also some disadvantages. The main thing in favor of the practice is its cheapness, one preparation of the seed bed answering for seeding both the grass and the grain. The disadvantages are the uncertainty of getting a stand, the liability of winterkilling if seeded late in the fall, and the great abundance of weeds which become established in the meadow.

The usual method is to seed such grasses as timothy, orchard grass, or redtop with wheat or rye in the fall and then to sow clover on the field late in the winter or early in the spring. Considerable grass and clover is seeded with oats or barley in the spring. There are several serious faults in these methods. The best time for seeding wheat or rye in the fall is too late for safe grass seeding. The young grass plants do not grow as rapidly as the grain and often do not get sufficiently rooted to survive the winter. Many soils run together and become so hard on the surface that clover seeded in the spring has no opportunity to become established. This is obviated to some extent by harrowing the grain with a spike-tooth harrow just before seeding the clover. It is impossible to estimate the quantity of clover seed wasted every year by seeding on hard-packed soils, but it is safe to say that it is a large percentage of the total sown.

The stand of grass is lessened by the space occupied by the grain. Sometimes a good stand of grass results from seeding with grain, but it is seldom that the perfection of stand for which one should strive is obtained. The term "nurse crop," which is often applied to a grain crop when it has grass seeded with it, is a misnomer. The grain does not act as a nurse for the grass in any sense of the word. There is the sharpest kind of competition among the plants for food, moisture, and sunlight. This may be better appreciated when the fact is taken into consideration that the grass if seeded alone in the fall would be ready to cut for hay by the time wheat is ripe, but it requires another year to produce a crop when seeded with the grain.

On some of the best grass soils of the corn belt timothy seeded in the fall with wheat makes sufficient growth to become detrimental to the yield of grain. Some farmers attempt to avoid this injury by sowing only a portion of the timothy seed in the fall and the remainder with the clover in the spring.

Many stands of grass are injured and sometimes destroyed in the two or three weeks following the harvesting of the grain. The young tender grass plants which have developed in the shade of the grain are exposed to the sun at the hottest time of the year. Summer weeds also have the opportunity to smother out some of the grass, as they make their best growth during the hot weather.

SEEDING WITHOUT A GRAIN CROP.

It may be said for seeding alone in late summer or early fall that it nearly always results in a better stand, the crop of hay is obtained as soon as if it had been seeded in a grain crop 10 months before, the grass is much freer from weeds, and usually there is a higher yield.

Spring seedings do not usually give as satisfactory results as those of late summer. This is largely due to the encroachment of weeds. Spring seedings of grass also involve a loss of the use of a field for an entire season. It is possible to harvest a crop of grain, then seed to grass, and get the hay crop as soon as it would have been obtained by seeding in the spring. Few of the hay grasses except the millets and Sudan grass will produce a crop of hay the same season they are sown. The rye-grasses are among the most rapid growers of the hay plants, but these will rarely produce a good crop the first season if seeded in the spring.

PREPARATION OF THE SEED BED.

In order to avoid losing the use of the land for an entire season and to allow for late-summer or early-fall seeding, the grass usually follows some small grain. The seed bed should be prepared as soon as possible after the grain is harvested. This preparation is best done with a disk harrow. Plowing deeply during that period is not desirable. There is not sufficient time before seeding to get the stirred soil compacted and united with the subsoil to allow the rise of moisture from below. A 3-inch mellow seed bed with firm soil beneath will give better results for summer seeding than one that is deeper. If the soil is so hard that it is impossible to cut it up with a disk harrow, it may be plowed shallow with a turning plow. A method used at the Tennessee Agricultural Experiment Station is to break the surface with a subsoil plow, making the plow furrows 2½ to 3 feet apart. This loosens the soil sufficiently to allow a disk harrow to work effectively.

Most grass seeds are very small and must have a fine, mellow soil in order that the seedlings may become established.

RATE OF SEEDING.

Rich land with a well-prepared seed bed does not require as much grass seed as thin land or land poorly fitted for seeding. From 5 to 10 pounds of grass seed to the acre evenly distributed would give an abundance of plants if every seed produced a plant. In practice, however, some of the seed fails to grow. This may be due to poor germination or faulty covering of the seeds, some being left on the surface and others buried too deeply. Most farmers use too little grass seed for the best results. From 20 to 30 pounds of seed per acre are generally sufficient, and this rate is usually more profitable than lighter seedings of mixtures. The size of the seed makes considerable difference as to the rate to use. Small-seeded grasses, such as redtop and timothy, do not require so heavy a seeding as orchard grass or rye-grass. Usually 10 pounds of timothy or 6 pounds of redtop are sufficient where these are seeded alone.

FERTILIZERS.

Hay crops respond very quickly to proper fertilization. There has been a decided change in the opinion of farmers and investigators in late years as to the crop in a rotation which should be fertilized. Formerly the grain crop received the fertilizer, and the residues left in the soil were supposed to be sufficient for the grass crop. Experimental evidence indicates that corn following a grass crop which has been fertilized will yield as well as, if not better, than when the same quantities of fertilizers are applied directly to the corn. Even highly soluble quick-acting fertilizers, like nitrate of soda, applied to a grass crop will sometimes show beneficial effects on succeeding crops for two or three years. These results may be explained by the greater accumulation of organic matter in the soil, due to the fertilization. It is a well-known fact that grass plants, with their enormous fibrous root systems, are highly efficient in maintaining the supply of vegetable matter in the soil.

FERTILIZERS RECOMMENDED.

Top-dressings of stable manure will increase the yield of hay. There is probably no better crop than grass on which to apply the manure. The usual method is to scatter the manure during the fall and winter after one crop of hay has been cut from a field. There are several good reasons for this practice. The danger of injury to the texture of the soil from driving on the field is lessened. There is less danger from introducing weeds, carried by seeds in the manure, to an old seeding than to a new one. The grass plants have become better established at the end of one season's growth and will make their maximum yield the second year if the soil is enriched.

Some commercial fertilizers will usually return a good profit when applied to the hay crop, but they should be used with some caution. It is a waste of money to apply nitrogenous fertilizers, such as nitrate of soda, sulphate of ammonia, dried blood, or cottonseed meal, to a clover crop or to a hay crop containing a high percentage of clover. These fertilizers, however, applied as a top-dressing in the spring, when growth first starts, to the second season's crop, when most of the clover has died out, will usually pay. At the Virginia Agricultural Experiment Station nitrate of soda returned a profit from its use when applied as heavily as 250 pounds per acre to a timothy-redtop-clover meadow from which hay had been cut one year. These fertilizers do not give equally good results when the meadow is 2 or 3 years old, probably because of the poorer stand and weakened vitality of the plants.

It is usually considered more profitable to apply phosphatic fertilizers to the crops preceding the hay than directly to the latter. In the customary rotation of corn, wheat, and hay the phosphates will give the best results when applied to the wheat crop. The effects of phosphorus continue for several years and benefit the hay crop as well as the wheat. There are such wide differences in the results obtained by different experimenters from the use of fertilizers that each farmer should consult his State experiment station before investing in these materials.

USE OF LIME.

A great deal of grass and clover seed is wasted every year from seeding on "sour" soils grasses and clovers, which will not thrive under such conditions. A large proportion of the lands in the older farmed sections have become poor in organic matter and have developed a condition commonly spoken of as "acid." The exact chemical nature of this condition is not so well understood as is the remedy. Lime has been found to correct this condition, so that many crops, like red clover and alfalfa, will grow after liming where they would not grow previously. The use of lime as a soil amendment has been practiced by farmers for several centuries. More than a hundred years ago it was known to benefit certain crops. In many farming communities in England and in some in this country it has been customary to lime the land regularly every six or seven years.

Lack of lime or an "acid" condition of the soil is not adverse to all plants. Redtop, Rhode Island bent, the fescues, and alsike clover will thrive provided the soil is sufficiently rich even when too "sour" for most other hay plants. Where it is not practicable to use lime and the soil is "sour" the above plants should be used.

Agricultural lime is found on the market in three forms: Burned lime, hydrated lime, and carbonate of lime. The consensus of opinion of most investigators of the subject is that it makes no difference which of these forms is used provided the same quantity of calcium, the essential element, is added in each case. Theoretically, 56 pounds of burned lime is equal to 74 pounds of hydrate of lime or 100 pounds of carbonate of lime. The carbonate of lime is usually the ground limestone, and it is often much cheaper than the other forms. When 2 tons of ground limestone can be applied for the same cost or less than it would take for 1 ton of burned lime, the former is preferable. When burned lime is used it should be applied at least two weeks before seeding.

Certain plants show clearly whether or not lime will be beneficial. Where red clover grows luxuriantly it is an indication that the land is not "sour" and will probably not give profitable returns for an application of lime. The quantity of lime needed depends on the degree of "acidity" of the soil. Ground limestone at the rate of 1 or 2 tons to the acre or its equivalent in burned or hydrated lime is the usual application.

The available evidence does not warrant the use of lime as a top-dressing on an established meadow. It should be thoroughly incorporated with the soil when it is being prepared for seeding the grass or for some preceding crop.

COMMON HAY PLANTS.

The following list includes most of the important hay plants for the northeastern part of the United States, gives in extremely brief form their chief characteristics, and points out their use. There are some plants which would be valuable hay plants if they were not so troublesome as weeds in cultivated fields. Others possess value but are inferior to the common better known species, so there is no particular reason for growing them.

Timothy.—A perennial and very valuable hay plant, too well known to require a description.

Red clover.—A biennial tufted plant, sometimes called the farmer's best friend. Makes a heavy growth on fertile well-drained soils. Not suited to wet or "sour" conditions. Benefits succeeding crops and makes a nutritious hay. Usually gives a light second crop in the fall.

Mammoth or sapling clover.—A large, coarse variety of red clover. Is ready to cut about two weeks later than common red clover and so combines well with timothy. Does not produce an aftermath.

Alsike clover.—A perennial clover which does best on moist soils. Will also grow on some soils which are too "sour" for red clover. Often used in mixtures with red clover to insure a stand. Makes a hay of good quality.

Orchard grass.—A coarse, tufted perennial grass. Will stand more shade than any other tame-hay grass. Makes good hay when cut young. Mature plants are tough and unpalatable.

Redtop.—A creeping perennial which will thrive under a great variety of conditions of soils and climates. It is the best wet-land hay grass and is sometimes used as a sand binder. Makes a fair quality of hay when cut early. Mature plants are wiry and undesirable. Hay buyers discriminate against redtop.

Alfalfa.—A most valuable perennial hay plant where it can be grown profitably. It produces three or four cuttings a year.

Tall oat-grass.—A tall-growing tufted perennial which possesses considerable merit for poor sandy soils. Makes a hay of good quality. It is not a heavy yielder.

Perennial rye-grass.—A tufted perennial which makes a vigorous growth while young. Does not yield sufficiently to be of much value as a hay plant.

Italian rye-grass.—A tufted annual or short-lived perennial, similar to perennial rye-grass but coarser and more valuable as a hay plant. It is better suited to the southern part of the timothy belt than to the northern part.

Millet.—A quick-growing heavy-yielding annual, suitable as a catch crop for hay. Needs a rich soil.

Cereals.—All the small grains make a fair quality of hay if cut early.

Oats and field peas.—These plants in combination are much used in the Northern States for hay, but are not adapted to the region south of Pennsylvania and Ohio.

Sudan grass and cowpeas or soy beans.—All of these make a good annual hay crop in the southern portion of the timothy region.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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FARMERS' BULLETIN 1171
UNITED STATES DEPARTMENT OF AGRICULTURE

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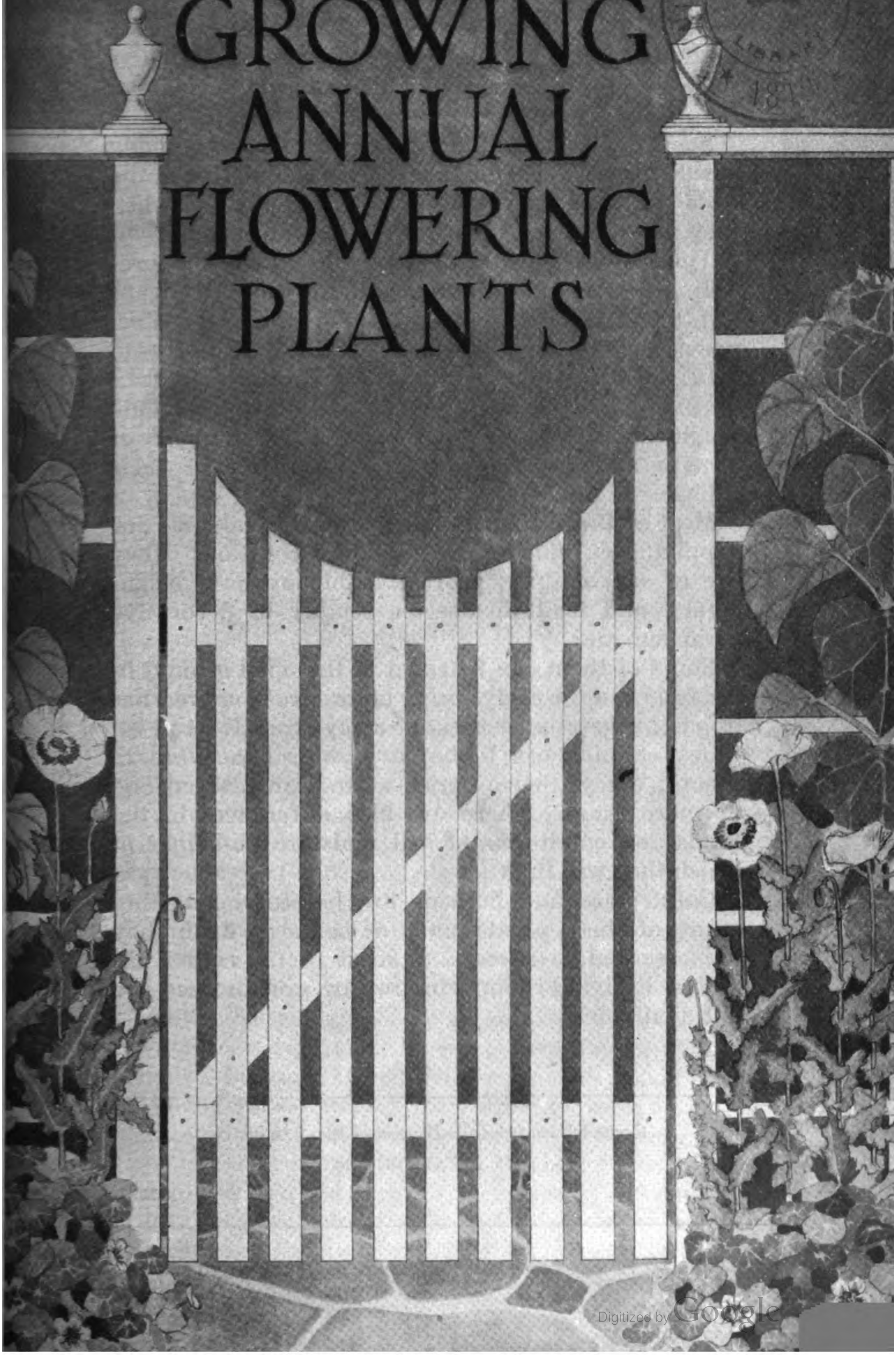
GROWING ANNUAL FLOWERING PLANTS



ANNUAL FLOWERING PLANTS are useful for quick though temporary effects and for flowers at a season of the year when blossoms on permanent plants are scarce.

Such plants in clumps in bays or pockets among shrubs or between herbaceous perennials make the beds and borders bright with bloom at a time when they might otherwise be dull and uninteresting.

Their quick growth makes them valuable in providing either foliage or flowers to fill temporary gaps in permanent plantings or to give a temporary effect where such planting does not exist. Several grow to a height of 6 feet or more, others hardly more than as many inches, while many are of intermediate height and show great variations in their habits of growth and in the color and character of their foliage.

Most of these annual plants are also valuable for supplying cut flowers for indoor decoration. They are of easy culture, profuse in bloom, have bright colors, and lend themselves readily to decorative arrangement.

Some of them can be sown in the open ground in the fall or in the early spring before freezing weather is past; others must be kept away from frost at all times. Some need to be sown where they are to bloom; others thrive better when transplanted one or more times. There are also differences in the kinds and conditions of soil moisture and light in which they will thrive best.

Coldframes and hotbeds are helpful in starting many of these plants, and for some of them they are essential to success, at least in the colder climates, if living-room windows or greenhouses are not available.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. February, 1921.

GROWING ANNUAL FLOWERING PLANTS.

L. C. CORBETT, *Horticulturist in Charge*, and F. L. MULFORD, *Horticulturist*, *Horticultural and Pomological Investigations.*

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USES OF FLOWERING PLANTS.

WHEN THE NEED for food, clothing, and shelter is reasonably satisfied, every human being, whether civilized or savage, begins to surround himself or herself with those things that please the eye. In addition to this, many people delight in the experience of making things grow. As a result of these impulses American home makers as a rule try to beautify the yards under their care, often achieving marvelous results under trying circumstances.

The most permanent and satisfying results are usually those obtained by a lawn as a foundation, with trees making a frame for the house and giving grateful shade, accompanied by shrubs and permanent flowers to round off the corners and give an air of naturalness and homelikeness.

In such a development there may be lacking during part of the season the brightness contributed by conspicuous flowers. Often this may be supplied by using annual flowering plants among the more permanent material, as most of them are gay with flowers at a season when most shrubs and perennials are not in bloom.

When permanent plantings, especially shrubbery beds, are newly set, they often look thin and ragged. Here, again, interplantings of annuals (fig. 1) may be helpful, either by filling the otherwise bare spaces with attractive foliage or with bright flowers or both.

Again, annual plants are useful on rented places where the tenant would seldom go to the expense of more permanent planting. They are quickly, easily, and cheaply grown, and their range of size and other characters makes it possible to secure temporarily many of the effects produced by the use of shrubs (fig. 2). These results may be obtained more quickly than with shrubs, but they are transient, as the first frost or at least the first freeze obliterates all their effect, and the winter appearance is as bare and bleak as though nothing had been done. Such temporary planting should not be relied upon when conditions will at all warrant the use of more permanent material, but its use should certainly be encouraged where planting for winter as well as summer effect is not possible.

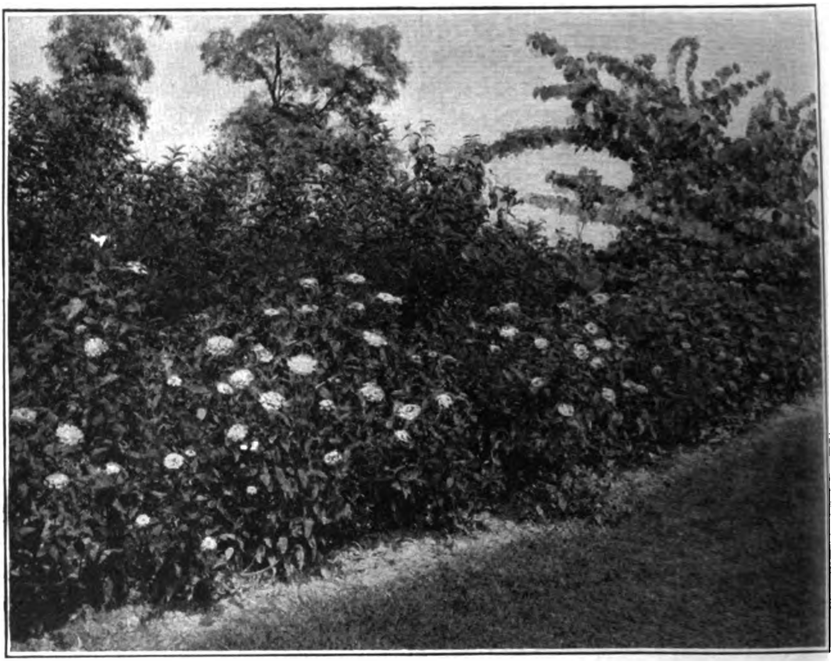

FIG. 1.—Annual plants used among shrubs for a temporary effect.

The tall-growing full-foliage plants, like tall castor-beans, sunflowers, and the sorghums, when massed against buildings, fences, or in front of other obtrusive objects or objectionable views, serve as attractive and efficient temporary screens (fig. 3). Moderate-growing broad-leaved plants, such as the dwarf castor-bean, can be used with advantage as screens for driveways or walks by placing a mass of the plants in the bay of the walk or drive. Lower growing plants when massed against a background of taller growing annuals or shrubs, either against buildings or on boundaries, are more effective than when used in beds in the open lawn. The formal bed, either in the shape of an oval, circle, or star, in the center of a lawn is generally more obtrusive than pleasing.

When annual plants are desired for use as cut flowers the best arrangement is to plant them in an area set apart as a flower garden or to devote a portion of the vegetable garden to the purpose (fig. 4). When grown for cut blooms only, the most satisfactory and economical plan is to plant them in long rows, with ample space between the rows and the individuals in the rows. Unless the plants are given sufficient room for full development, the flowers which they produce will be inferior in size and form. To secure the best results from plants to be used in this way, rich soil, ample space, and good culture are essential. They may be grown with horse cultivation, as vegetables are grown.

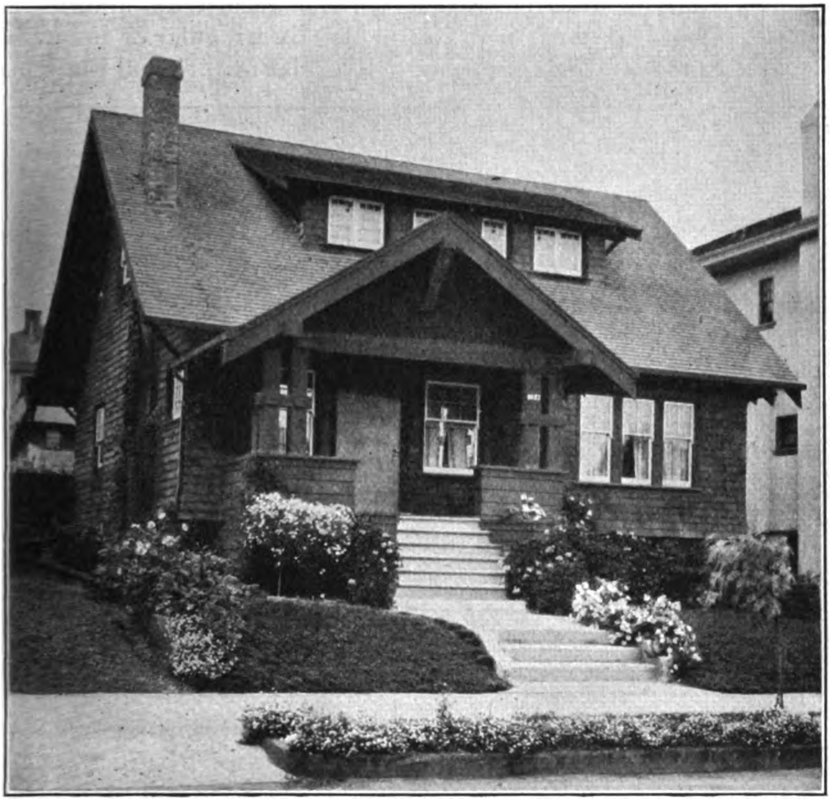

FIG. 2.—Annual flowers used instead of more permanent material as the setting for a house.

If the flower garden is a distinct feature of the place and its mission is to furnish an attractive retreat or a retreat and cut flowers, its general plan may be more pretentious; the straight rows may give place to irregular groups or masses, or even to formal beds and designs, so long as these are not made the leading feature in the general adornment of the grounds. In fact, such a garden should be more or less inclosed from the rest of the grounds by border plantings. These need not be over 3 feet high, or they may be of the tallest growing kinds. The design within the garden may be either formal or informal, with beds and walks of formal geometrical designs of either straight or curved lines, or both; or they may be irregular in the extreme with no set design. If the walks and beds are laid out in a formal fashion the plantings may be made in geometrical designs, as carpet bedding if desired, or it may be strictly irregular or informal (fig. 5). In the informal garden only irregular or informal planting is appropriate. A piece of ground irregular in outline or rough and uneven in surface lends itself more readily to the informal garden than to the formal. The paths in such a garden can be irregularly curving and can be made to present endless opportunities for exhibiting plant characteristics. On level ground with a regular outline the formal garden is appropriate and often the simplest to develop. By adopting the informal method of planting, however, the formal garden can be made to present anything but a stiff and formal effect. If the garden is to be permanent, the walks should be of a permanent and satisfactory material. Turf is probably the most generally satisfactory walk surface as well as the most economical. Brick, stepping stones, and gravel are also desirable under some conditions.

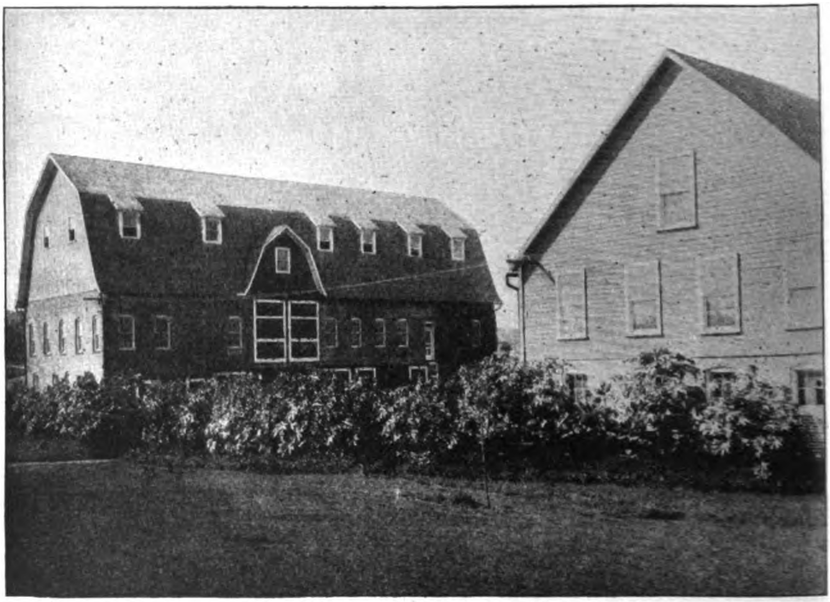

FIG. 3.—Annuals used for a temporary effect where permanent plants have not been established.

If a fixed design is adopted, the soil in various areas of the garden may be modified by the addition of sand, muck, or clay and by the use of plant foods to adapt particular areas to the needs of special plants. Those which enjoy a dry, sandy soil can be provided for, while those which thrive best in a heavy soil can also be accommodated. If, on the other hand, a less formal and fixed character in the garden seems desirable, the whole area may be annually spaded or plowed up, the walks given a new course, and the general scheme of planting changed. Such an arrangement will give variety and novelty to the garden and for most purposes will prove quite as successful as the more permanent arrangement. During wet periods, unless the soil is of a sandy character, the lack of an improved walk surface will prove a disadvantage.

Often annual plants can be used appropriately on the grounds about public buildings and in parks. Frequently the design of such grounds demands formal plantings (fig. 6), and many of the annual plants lend themselves admirably to such use.

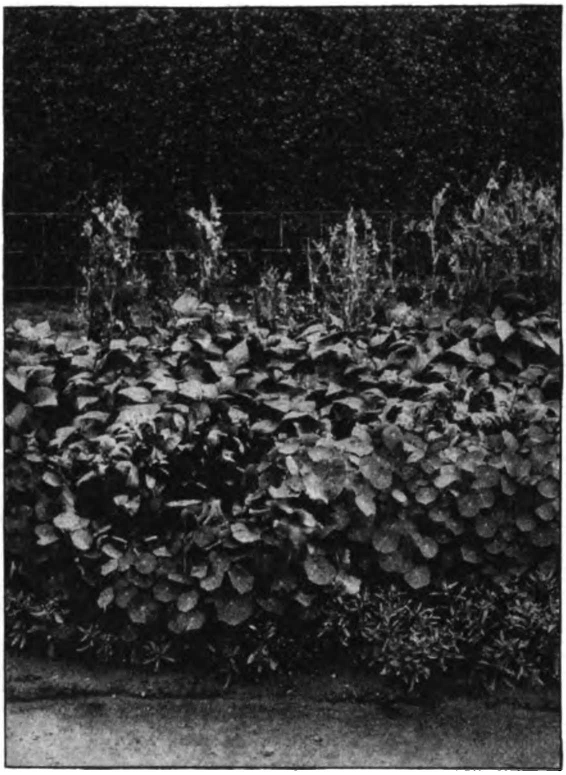

Fig. 4.—Annual flowers bordering a path in a vegetable garden.

GENERAL CULTURAL SUGGESTIONS.

PREPARATION OF THE SOIL.

Soil for the growing of annual plants needs to be well supplied with available plant food and should be reasonably retentive of moisture, though well drained. In short, because the plants make a quick growth they must be provided with good growing conditions in order to enable them to make that growth. Among these plants, however, there is a great difference in the requirements, some preferring a light soil, others a heavy one; some needing very rich soil, others giving more and better flowers on a comparatively poor one; some wanting considerable moisture either in the soil or atmosphere or both, others succeeding under much drier conditions; some liking full sunshine and hot weather, others preferring shade or cool weather or both.

The best soil for most of these plants is a light rich loam well supplied with rotted manure. A subsoil taken from the bottom of a cellar in excavating for a house is not suitable material upon which to depend as a satisfactory foundation for a flower bed. Where the soil is not naturally of the desired character, often much may be done to modify small areas to make them ideal for the culture of annuals.

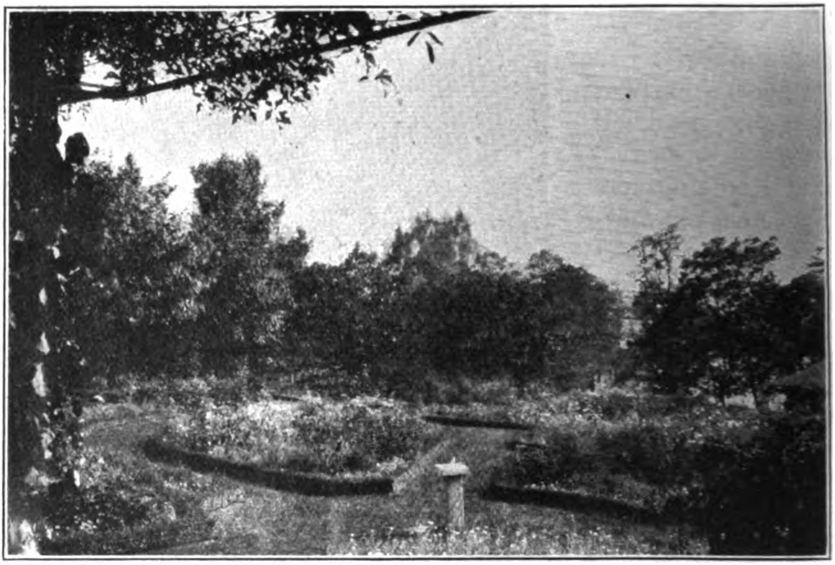

FIG. 5.—A garden with a formal design but informal plantings.

If the soil is thin and poor, a bed 2 feet deep can be excavated and filled with soil specially prepared for the plants it is intended to grow. More clay can be used in the soil for plants requiring heavy soil and more sand and leaf mold in the soil for plants requiring lighter soils.

An ideal soil for general purposes can be made from sods of bluegrass from a rather heavy clay loam rotted for a year, then mixed with equal quantities of rotted manure, leaf mold, and sand. The manure and sod can be rotted together for a year, if just as convenient. A specially prepared soil of this kind will probably not be benefited much by another coat of manure the second year, but after that it should have annual dressings. Where good garden soil or other rich soil of suitable texture is available, probably the more common practice is to make the bed of suitable depth and fill it with this soil well enriched with rotted manure. For permanent beds a careful preparation with good soil of proper texture is well worth the effort. If for any reason such thorough preparation is not considered advisable, as on a place that may not be used for more than a year or two or on rented property where the tenure is regarded as comparatively temporary, the attempt to have annual flowers should not be abandoned, as even with much less preparation results may be obtained that are well worth the effort if the kinds of flowers grown are selected with consideration of the conditions that prevail. Rotted manure, hen manure, prepared sheep or cow manure (obtainable from dealers in agricultural supplies), cottonseed meal, bone meal, or some similar organic manure, however, is almost essential to success. The value of these fertilizers is about in the order named. There should be as much rotted cow manure, or even rotted horse manure, worked into the soil as can be done reasonably. Less hen manure should be used, as it is several times richer than cow or horse manure. The prepared cow and sheep manure can be used at the rate of 1 pound for 3 square feet, and the cottonseed meal and bone meal at the rate of 1 pound for 5 square feet. All these materials should be thoroughly worked into the soil. They will not bring satisfactory results, however, unless the ground is reasonably good to start with, especially as to texture.

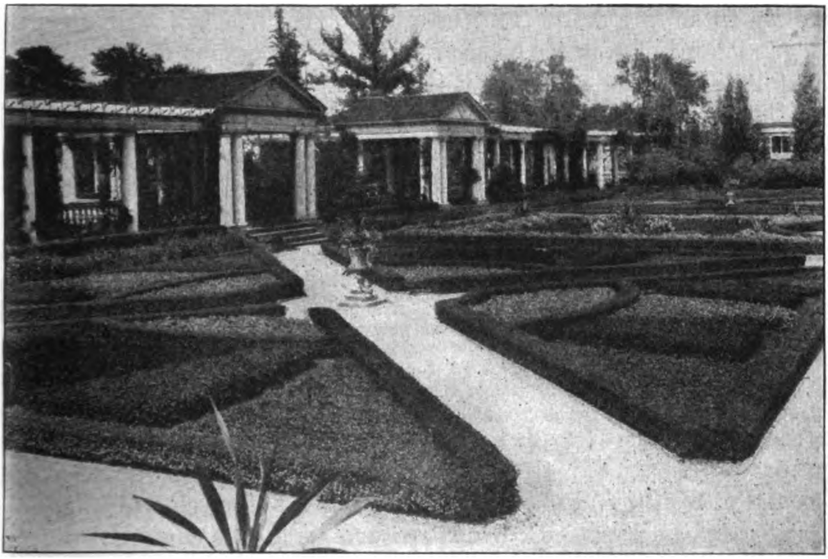

FIG. 6.—A formal planting on the grounds about a public building.

When larger areas are used for flowers, as in a special garden that can be handled with a plow, like a large vegetable garden or part of the vegetable garden, soil-improvement crops, like crimson clover and vetch in winter or cowpeas in summer, may be used to enrich the soil and thus prepare it for another season's crops. It is possible sometimes to adapt some of these soil-improvement crops to the smaller areas of flower beds, although it is seldom advisable, as the limited quantity of fertilizing materials usually needed can ordinarily be provided for the comparatively small areas devoted to these plants about the home.

WATER.

Next in importance to providing a good soil supplied with organic fertilizing material is a proper water supply. The provision of a deep soil of proper texture well enriched with organic manure makes a water-holding reservoir that acts something like a sponge in its ability to supply water for the plants. Such a soil will absorb a large amount of water whenever given an opportunity and will give it up readily to the plants as it is needed. On the other hand, provision must be made so that when such a soil has absorbed all that it is capable of properly holding, the surplus will drain away. If the surplus water does not naturally pass away freely, then artificial drainage must be provided. In poorly drained soils, beds specially prepared, as already described, should be excavated 3 feet deep instead of 2 feet, and in the bottom a layer of stone should be placed, covered by inverted sods, which in turn should be covered by 2 feet of soil (fig. 7). This layer of drainage should be given some suitable outlet to carry off any water that might otherwise collect in it. This would preferably be by a drainpipe taken to a sewer or to some suitable outlet. A stone drain may be used, but it is likely to become clogged.

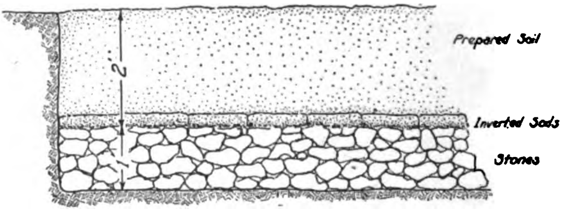

FIG. 7.—A bed specially prepared for plant growth where the normal drainage is inadequate.

In addition to drainage, another essential is sufficient water during the growing season. Throughout much of the United States the natural rainfall on a bed well prepared, as already described, would be sufficient for success in most seasons. Beds close to a house, so that much of the rain is kept off by the building, need the natural rainfall, supplemented by occasional waterings. Irrigation is also necessary in dry climates and in moist climates in unusually dry seasons; also on sandy or other unusually dry soils. The amount and frequency of watering will depend both upon the dryness of the atmosphere and of the soil. A well-prepared retentive soil 2 feet deep would probably not require watering more often than once a week, except possibly in the driest parts of the country, where the evaporation is excessive. Gravelly or sandy soils, especially if not well provided with organic matter, may require a thorough watering every other day. The watering should be done as infrequently as the soil and the climatic conditions will permit. Only experience can teach the best method. Too frequent watering is as bad as too long an interval between waterings. If watered too often the surface soil is kept moist and the root growth is encouraged near the surface. A day's neglect or unusual drying conditions will dry the feeding ground of the roots and kill them. But if the roots are required to go deeper by permitting the surface to become dry for 2 or 3 inches between waterings there will be less danger of unfortunate results from unusual conditions or a slight deviation from the regular schedule of watering.

STARTING THE PLANTS.

The plants considered in this bulletin are those that can be started readily from seed in the spring and will give bloom or satisfactory foliage effects the same season. Nearly all of these can be started in the open ground over at least a large part of the United States and will give the desired results before they are cut off by frost. In order to get a longer season of effect from the plants, many of them are usually started under glass, or early plantings are started that way. In the more northern sections of the country some kinds must be started in this way in order to have a season long enough to mature; others so that they may become established before the coming of dry or hot weather, which would be injurious to the young plants, but would not affect established ones.

Seed sowing.—All of the plants mentioned in this bulletin can be propagated from seed. In some cases, however, the seeds require special care in order to insure a good stand of plants, and it is for that reason that the particular methods necessary for that purpose are described.

A few of these plants must be sown where they are to mature, as they will not stand being moved. Many may be sown where they are to grow, though most of them are helped by one or two transplantings. Because better plants are obtained by transplanting, most annuals are sown in seed beds and moved to their permanent places. Such seed beds should be in well-prepared mellow soil, preferably somewhat protected from drying winds. If the soil is not mellow, the seedlings, especially from the smaller seeds, will have trouble breaking through any crust that may form, especially if moisture conditions are not exactly right. Protection from winds also helps to maintain uniform moisture conditions. The timely use of a watering can is often a great help in promoting germination, but care should be taken not to use it too much. Seed beds require frequent light waterings rather than the infrequent drenchings best suited to more mature plants.

Seeds may be sown either broadcast or in rows. The inexperienced gardener should plant seeds in rows, especially for slow-germinating seeds, as quick-starting weeds may be more readily recognized and removed with less danger of disturbing the germinating seeds. Those starting near the seed row may be removed at once with great care or may be left until the seedlings are well sprouted. The dates of sowing the different kinds of seeds will be mentioned under the respective headings in connection with the discussion of other special cultural requirements.

Germination.—The germination of seeds depends upon a proper degree of heat, moisture, and oxygen from the air. All three of these conditions must be present to insure the best germination of the seed. Some seeds germinate best under a high temperature (80° to 90° F.), while others do best at a low temperature (40° to 60° F.). For most seeds, however, a soil temperature of 65° to 70° F. with an air temperature of 60° F. will prove very satisfactory for germination. Strange as it may seem, nature maintains conditions during the early part of the growing season approximating those above specified.[1] But naturally the high temperatures are much later in the season than the low ones. In order to obtain the higher temperatures early in the season a greenhouse, hotbed, coldframe, or a sunny kitchen window must be used.

Moisture.—Seeds in most cases grow best when the moisture in the soil is slight rather than excessive. A good test for moisture is to take a handful of soil and compact it gently in the palm of the hand by closing the fingers. If when released the soil remains solid and retains the impressions of the hand, it is too wet; but if when released it springs back and slowly crumbles or parts, it is in ideal condition for seed sowing. Such soil is well aerated, while the soil containing an excess of moisture has the air largely replaced by water.

The seed bed should be carefully guarded against extremes of moisture. It should not be allowed to get too wet and remain in that condition for any length of time; neither should it be allowed to get too dry. In the open these conditions are not likely to occur during a normal season. However, there are frequent exceptions. If too wet, little can be done to overcome the bad results, but if drought occurs irrigation will remedy the evil. Under artificial conditions, such as are obtained in a greenhouse, hotbed, or coldframe, the moisture content of the soil of the seed bed can be very carefully controlled. The confined atmosphere of such a structure prevents rapid or excessive evaporation, while any loss of moisture from the soil can be made good by watering. On a small scale the same results can be approached by placing a pane of glass over the receptacle in which the seeds are sown.

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[1] Reading of soil thermometers. (Tables.) *In* New York Agr. Exp. Sta., 2d–13th, 15th–17th Ann. Rpt., 1883–94, 1896–98. 1884–1899.

Soil temperature.—Slight variations in the temperature of the soil in which seeds are sown are usually a benefit rather than a hindrance to germination. With the grasses and clovers and probably with practically all other plants germination is more rapid and more complete in seeds subjected to alternations of temperature than in those kept under constant temperatures. Under normal conditions the warming of the soil during the day and the cooling at night furnish sufficiently wide variations. While these variations are less easily controlled than the variations in moisture, yet in structures such as hotbeds and coldframes the change from day to night temperature will be perceptible.

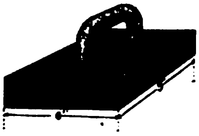

FIG. 8.—A float for firming the soil.

Seeds in order to germinate promptly must be placed under conditions which will enable them to take up moisture readily, and at the same time they must have a temperature which will be congenial to the young plant when it appears. The soil is the medium by which heat and moisture, under normal conditions, are transferred to the seed. In order to insure a quick exchange of moisture from the soil to the seed, the soil should be carefully firmed or compacted about the seed. By compacting the soil about the seed the capillary power of the soil is increased, and as the seed becomes an intimate part of the soil, the soil moisture is thus more quickly brought to the seed. In outdoor operations large seeds may have the soil compacted about them by tramping the row with the feet, while fine seeds may be treated by resting a board over the row and walking upon it from end to end. In hotbeds, greenhouses, and coldframes the compacting of the soil is usually accomplished by the use of a float, which consists of a piece of board about 6 inches wide and 9 or 10 inches long, with a handle attached, as shown in figure 8.

For all conditions save in the open, seeds may be sown in seed pans or in flats, as shown in figure 9. These boxes can be very conveniently and cheaply made from the pine boxes largely used for packing canned goods, soap, or other merchandise, usually 9 or 10 inches deep, which is sufficient to permit cutting them with a ripsaw into three sections, each about 3 inches high. The top and bottom of the box will each make a complete flat, while the middle section will be a frame which can be provided with a bottom by the destruction of a box for three sections; i. e., four boxes will furnish nine complete flats. Seeds may also be planted directly in the soil of the hotbed, coldframe, or in that upon the greenhouse bench as well as in the garden. Here, too, they may be sown broadcast, but it is preferable to sow in rows.

In covering seeds the rule under artificial conditions is to bury the seed to the depth of its greatest diameter. In outdoor culture, however, this is not the practice; seeds are usually covered about three to five times their diameter. With seeds the size of a grain of wheat it is safe generally to plant them 1 inch deep, and for those the size of beans 2 inches deep. Small seeds, the size of those of petunia or tobacco, should be scattered over the surface and the soil compacted with a float.

Transplanting.—The young seedling plants which are to be grown for their bloom should be transplanted as soon as the first true leaves are formed, so that they will stand at some distance from one another. For small, rather slow growing plants, such as pansies, 1 inch apart each way will afford ample room; with most plants 2 inches each way will be best; but with robust-growing plants, like the castor-bean, 4 inches will not be too much. With such vigorous growing plants, however, it is best to place the seeds directly in pots or cans in order to prevent disturbing the roots of the young seedlings as well as to afford them ample space. If ordinary pots are not available, paper pots may be obtained cheaply or old strawberry boxes may be used. Transplanting has a tendency to make the plants stocky and provides opportunity for the development of an extensive root system.

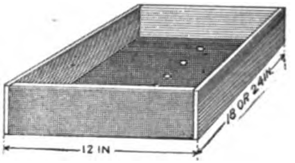

FIG. 9.—A flat.

The pleasure derived from floral decorations depends not only upon the perfection of the flowers but upon having a continuous display throughout the season. With most of the garden annuals early bloom can not be secured if seed sowing in the open must be relied upon exclusively. Fortunately, the gardener's art has devised cheap and efficient means, as it were, for anticipating nature. By the use of coldframes at the South and hotbeds at the North the season can be advanced several weeks. In the latitude of Washington, D. C., the time of sowing seed requiring the higher temperatures for germination can be advanced from May 1, the normal date of sowing in the open, to March 1, a gain of two months. Seed sown in a gentle hotbed at this date will give plants which, if properly handled, will forward the season of bloom two weeks.

HOTBEDS.

Hotbeds are usually constructed in one or the other of the following ways:

Temporary hotbeds.—A temporary hotbed may be made by using fermenting stable manure from grain-fed horses, preferably that with a small quantity of straw or litter in it. The manure should be placed in a broad, flat heap and thoroughly compacted by tramping. A heap 8 or 9 feet wide and any multiple of 3 feet in length, with the manure 14 to 16 inches deep, will give sufficient heat for the latitude of New York City and of Kansas City, Mo. Farther north, the heap should be made deeper and broader. Upon the surface of the manure heap a frame made like that shown in figure 10 will afford ample space for the development of the plants within. The backboard of this frame is usually 12 inches wide and the front 8 inches, and the two are connected by a tapered board 12 inches wide at one end, 8 inches wide at the other, and 6 feet in length. The back and front of the frame are made in multiples of 3 feet in length, with an inch added for each division space between sash, which is provided for by the use of a T-shaped piece let into the frame to stiffen it and serve as a guide for the sash. The manner of making the guide as well as its appearance when in place is shown in figure 10. A cross section is illustrated by figure 11. If severe weather is likely to occur during the time the hotbed is in use, the frame should be banked with manure to give additional heat and protection. After placing the frame upon the manure heap, about 3 inches of good garden loam should be scattered uniformly over the area inclosed by the frame.

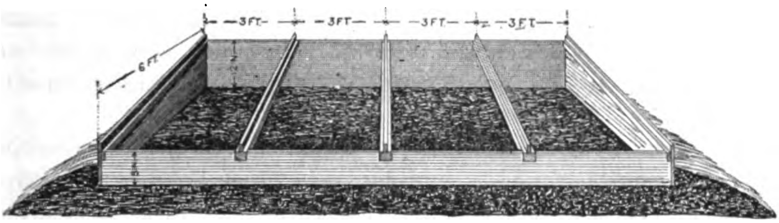

FIG. 10.—A frame to carry the sash of a hotbed or coldframe.

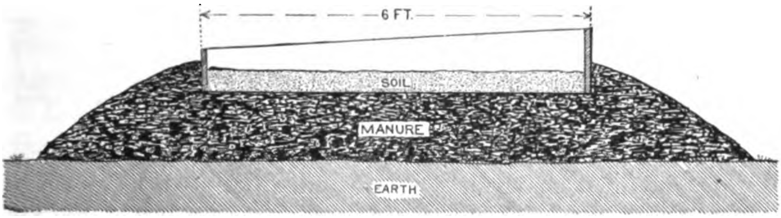

FIG. 11.—Cross section of a temporary hotbed.

Place the sash in position immediately and allow the bed to heat up. Do not plant any seeds in the bed until the temperature begins to subside, which will be in about three days after the sash are put in place. When the temperature has fallen to 85° or 90° F. planting may be safely begun.

Permanent hotbeds.—A permanent hotbed may be so constructed as to be heated with fermenting manure or by radiating pipes from the dwelling or greenhouse heating plant. For a permanent bed, in which manure is to supply the heat, a pit 2 to 2½ feet in depth, according to the latitude in which the work is to be done, should be provided. The sides and ends may be supported by a lining of planks held in place by posts 4 feet apart, or, better still, a brick wall 9 inches thick, as shown in figure 12, may be used. In either case the pit lining should come flush with or above the surface of the soil. The site for the pit should be on naturally well-drained land, and a tile drain from the bottom of the excavation should be provided to prevent water from accumulating in the pit and stopping the fermentation of the manure during the period the hotbed is in use.

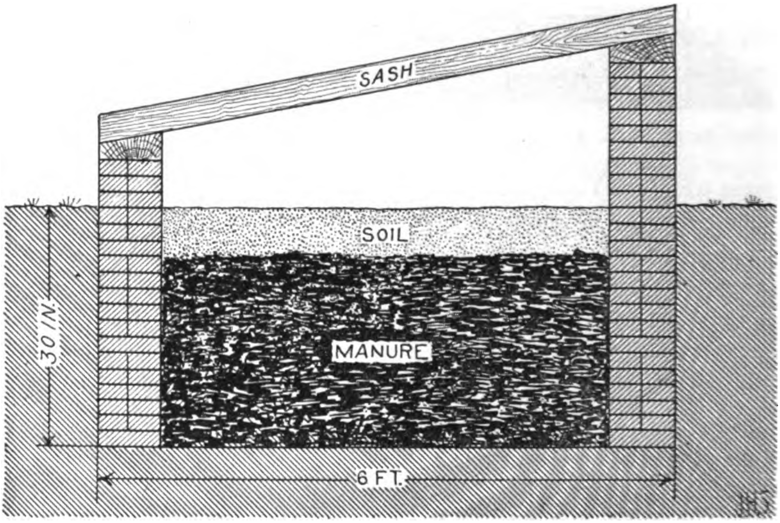

FIG. 12.—Cross section of a permanent hotbed or pit.

Standard hotbed sash are 3 by 6 feet in size, and the interior crosspieces for holding the sash are 1 inch wide. The pit, therefore, should be some multiple of 3 feet 1 inch in length less 1 inch, and the width should be the same as the length of the sash—6 feet. The plank frame or brickwork of the pit may be extended above the surface of the ground sufficiently to allow for placing the sash immediately upon these permanent structures, or a frame such as is described in connection with the construction of a temporary hotbed (fig. 10) may be used. In the autumn the pit should be filled with leaves or straw and covered with loose boards or shutters to prevent it from becoming filled with snow and ice in the North, so that it may be ready for use early in March there, or in January or February farther south.

Sash.—Hotbed sash should be constructed of white pine, cypress, or redwood, and the sash bars should run in one direction only and that lengthwise of the sash. The bars may be braced through the middle by a transverse bar placed through the long bars below the plane occupied by the glass. The two ends of the sash should be made of sound timber, 3 inches wide at the top and 4 inches wide at the bottom end, mortised to receive the ends of the sash bars and with a tenon at the ends to pass through the side pieces, which should be 2½ inches wide.

Glazing.—Placing the glass in the sash is one of the most important operations in the construction of a hotbed and is also one of the factors which largely determines the success or failure of the bed. The glass should be bedded in putty, i. e., the rabbet in the sash bar which is made to carry the glass should be filled with soft putty, and the glass, crowning side up, pressed firmly into the bed of putty and securely fastened with shoe nails or wire brads. Glazing points are not sufficiently secure. The first glass to be placed in any frame is a bottom light, i. e., the pane nearest to the front or lowest side of the hotbed when the sash is in place. The next light should be bedded in the same manner as the first and so placed as to lap about three-sixteenths of an inch over the top edge of the one first placed, like shingles on a roof. Brads should be driven below the lower corners of the second pane in order to prevent it from slipping down over the under one. The same method of procedure should be continued until the frame is filled with glass.

Size of glass.—While a frame with two courses of glass will admit a little more light than one with three, the breakage is somewhat less with small glass and the cost of repairing correspondingly less, and for these reasons the 3-course frame is more desirable. Nowadays many hotbed sash are made with a groove or slot into which the glass may be slipped and fastened at the bottom by brads to prevent them from slipping out. Grooved sash have the commendable feature of being cheaply and quickly glazed, but as the glass can not be lapped and as no putty is used the sash are not water tight and do not furnish as good protection from the wind as those in which the glass is bedded in putty.

Care of a hotbed.—At the North, in addition to the glazed sash, board shutters, straw mats, or mats of burlap or carpet will be needed as an additional protection during cold nights. During bright days, even when the temperature outside is near the freezing point, it will be necessary to lift the sash a little at the high side of the frame to allow the hot air to escape and prevent injury to the young plants.

Watering.—Hotbeds should be watered in the morning only, and then only on bright days. Watering at night is dangerous, as the operation necessitates the lifting of the sash and the loss of the accumulated heated air, and the water itself lowers the temperature of the soil, so that in cold weather there is greatly increased danger to the plants from frost. Then, too, the excessive moisture resulting from dampening the leaves and confining them during the night provides congenial conditions for the development of mildew and damping-off fungi.

COLDFRAMES.

Coldframes are devices intended to protect plants from cold, without forcing them into growth. They differ from hotbeds in that no artificial means of heating are employed. The coldframe in its simplest form consists of a frame constructed like the one described in the chapter on hotbeds and illustrated in figure 10. When complete, the frame is placed upon a sheltered, well-drained piece of ground convenient to some main line of traffic between the house and some other important and frequently visited portion of the grounds. The frame, as above stated, is made to carry hotbed sash. The glass allows the sun during bright days to temper the air of the frames, so that by properly covering them at night with shutters, straw, or jute mats the heat can be retained and the plants within safely carried through severe weather. The frames may be banked with earth as an added precaution against cold.

Care of coldframes.—The chief precaution which must be observed in the management of a coldframe is that of proper ventilation. The object of this device is to retain plants in a healthy condition without adding to their growth. It is therefore very essential that the temperature of the frame at all times be kept at a degree which will not induce rapid growth. High temperatures and abundant humidity induce growth. The management of the frame should be so directed that during bright, sunny weather the sash may be lifted sufficiently to admit outside air in order to preserve a low temperature about the leaves of the plants. In some cases it will be found that during bright days even in midwinter the sash will have to be removed from the frame for a few hours at midday in order to preserve a sufficiently low temperature. On the other hand, care should be exercised in ventilation and watering so as not to reduce the temperature of the frame late in the afternoon, as such treatment is liable to lead to frost injury.

Plants for coldframes.—It stands to reason that only the hardiest plants can safely be carried over winter in a coldframe. Many of the plants which are grown as annuals will, with protection, become perennials, or can be made to give a much longer period of bloom if sown in the autumn and carried over winter in a coldframe. Among plants which will be greatly benefited by such treatment are pansies, dianthus, and chrysanthemums.

PITS.

The pit is a more elaborate and efficient coldframe which, as its name indicates, consists of an excavation. This excavation may be from 2 to 4 feet in depth, with sides protected by plank or brick walls, as shown in figure 12, upon which a frame similar to the one described for the coldframe is placed and covered with sash. The pit has an advantage over the coldframe for some purposes. It can be used, for instance, to store some of the hardier flowering plants which are to be placed in tubs or vases about the lawn during the summer. Plants in a pit are protected by the warmth of the soil. In latitudes where the soil does not freeze to a depth of more than 10 to 15 inches the pit will be found of greatest use. Seedling plants may be held over winter in trays or flats in pits as safely as in frames.

Management.—The same precautions in regard to ventilation, covering, and watering must be observed in the care of a pit as in the case of a coldframe.

THE CULTIVATION AND USES OF ANNUAL FLOWERING PLANTS.

As already outlined, annual flowering plants may be used both as backgrounds and foregrounds in planting home surroundings. Their adaptability for these various purposes depends largely upon their relative heights; therefore, for purposes of discussion the plants have been grouped somewhat arbitrarily according to their usual heights. In addition to the common name, the scientific name is given in a footnote in order positively to identify the plants, as common names often differ in different localities. Then, too, in many cases seedsmen list their seeds under the scientific names, while others use the common ones. There have been included, also, the general color range of the plants and their adaptability to conditions of sun or shade and relative hardiness. Their relative hardiness or susceptibility to frost is important as a guide to the method of starting seedlings. The very hardy can be sown before freezing weather is past; that is, while the ground still freezes at night but thaws during the day. They may often be sown late in the fall for germination in the early spring. The hardy are those that can be sown after freezing weather is past and will stand frosts. These correspond to such vegetables as beets, radishes, and lettuce and should be planted as soon as the ground is dry enough to work.

Half-hardy plants are those that can be sown in the open ground a week or two before the last frost may be expected or that can be started under glass and transplanted to the open ground while there may still be danger of slight frosts, but which do better with temperatures above the frost point. Seeds of such plants may be sown about the time leaves begin to appear on the trees that put out their foliage earliest or about the time the earliest string or snap beans are sown.

Tender plants are those that are checked or stunted by an approach to frosty conditions and are injured by even the slightest frost. Many of them must be started under glass, especially in the North, in order to have a sufficiently long season in which to develop. Most of them are natives of tropical or subtropical countries and require a long season for growth. Their seeds should not be put in the open ground until all danger from frost is past, which is about corn-planting time or when white-oak leaves are the size of squirrels' ears. Tender plants should not be taken from frames and put into their permanent places until 10 days later than this.

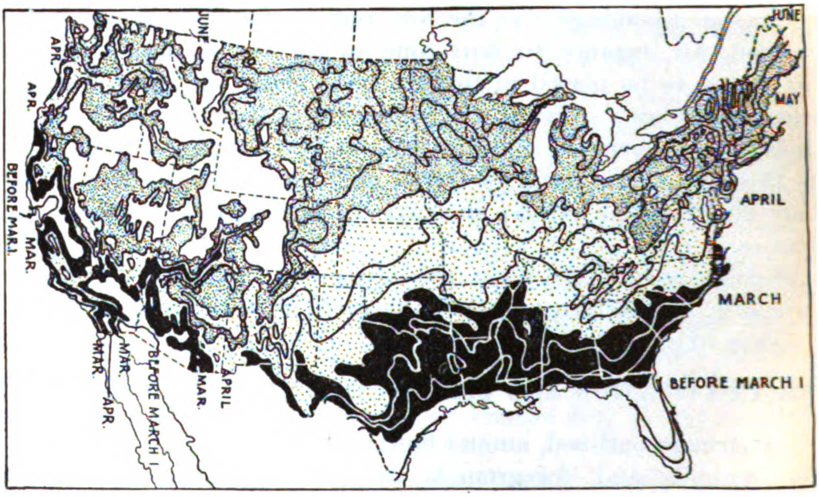

FIG. 13.—Outline map of the United States, showing the date of the average occurrence of the last spring frost.

From the foregoing it will be seen that the time of planting the different flowers will depend on the forwardness of the season, especially as regards freezing and frost. The conditions with respect to these factors vary greatly, the map shown as figure 13 giving some idea of the approximate date of the last frost at different points in the United States. In the map the shaded portions are those in which the last frost occurs in March or in May, the lines in them indicating intervals of 10 days. The lines in the unshaded portions similarly indicate 10-day intervals. From the eastern foot of the Rocky Mountains westward only the monthly intervals are attempted to be shown, as frost conditions there are governed almost entirely by elevation rather than by latitude, which makes it almost impossible to give any satisfactory idea within the limits of this map.

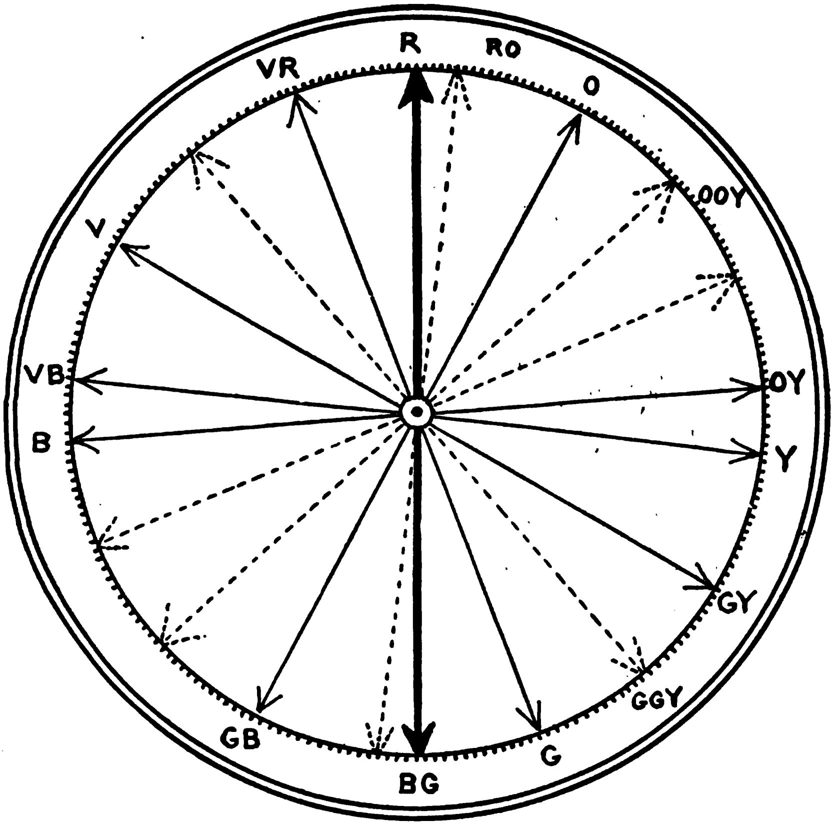

Fig. 14.—Diagram showing good and bad color combinations. Colors immediately adjacent to one another or opposite one another are appropriate for use together. Those between should be separated by masses of foliage or by white flowers. B=blue, G=green, O=orange, R=red, V=violet, Y=yellow.

Most of the annual flowering plants are so vivid in their colors and when planted are used in such large masses that more care is probably required to avoid bad color combinations than with other classes of plants. When used in clumps in shrubbery beds so that there is other foliage to separate the colors, there is much less danger of getting bad combinations than when large masses of different kinds of annuals are used in a garden or in a single border. The colors found in the different varieties of a single species usually will not clash. As a guide in selecting flowers that may be safely used near one another, the color diagram shown as figure 14 is presented. The colors opposite one another on the diagram are safe to use together, as well as those close beside one another, but those at right angles to one another—that is, the intermediate ones—are not safe to be used except by those who have made an extended, careful study of color combinations.[2]

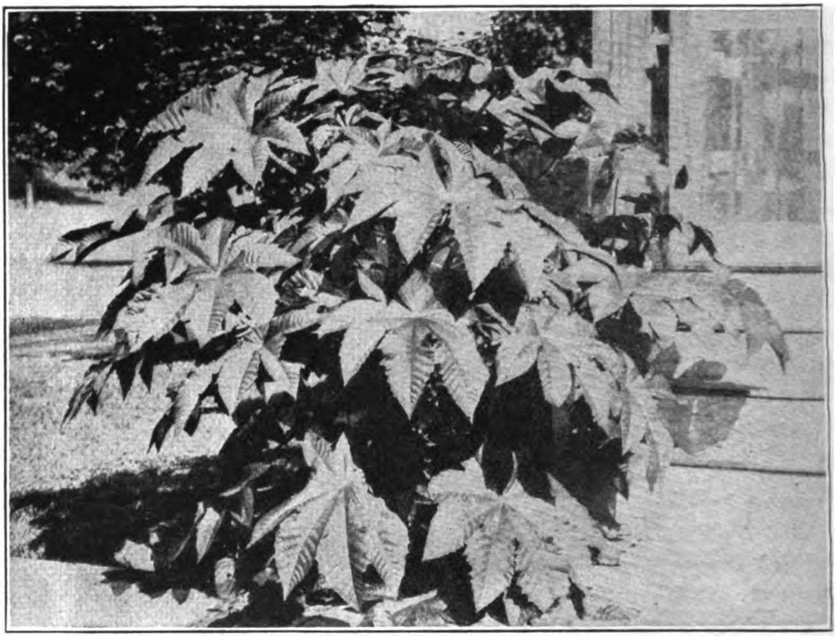

FIG. 15.—Castor-bean.

BACKGROUNDS AND SCREENS.

Among annual flowering plants there are a few that are excellent for backgrounds and screens. Among these are castor-beans, cosmos, sunflowers, sorghums, feterita, milo, broom corn, and even Indian corn.

Castor-bean.—The castor-bean, or castor-oil, plant[3] is especially valuable because it is one of the few annuals which can be used to produce a semitropical effect (fig. 15). Its rapid growth, large size, and easy culture make it valuable as the central object in groups where rich, luxuriant growth is required. The variety of color in the foliage of the different sorts, ranging from green to deep bronze, is of value in giving contrast, and when used in combination with cannas, caladiums, coleus, or scarlet sage most striking effects can be produced. As a background for lower growing plants, the castor-bean has no equal among garden annuals. Only the annual climbing vines when provided with suitable supports equal it as a low screen. It can be used with good effect in groups, as masses along shrubbery borders, as belts for covering and shutting out undesirable views, and singly against buildings or to fill gaps in newly planted shrubbery. This plant loves a rich soil, plenty of moisture, full sunlight, and great heat. In the North it is most satisfactory when started in a gentle heat four or five weeks before the last frost. A hotbed, greenhouse, or living room can be used for the purpose. As soon as the first true leaves have formed, the young plants should be pricked out into small boxes or pots, or they may be started in strawberry boxes or in paper pots, with one seed to a pot. They should be kept growing slowly until all danger of frost has passed, when they may be transferred to the open. After transplanting the young plants it is desirable that they have sufficient room to prevent them from growing too tall and consequently from losing their lower leaves. They should be from 3 to 6 feet apart, depending on the variety.

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[2] A suggestion as to the reasons for this is given in Farmers' Bulletin 1087, entitled "Beautifying the Farmstead."

[3] *Ricinus communis* L.

If planted in the open ground about the date of the last frost, or 10 days before it would be safe to set plants in the open, they will make a growth of 4 to 6 feet in 10 weeks. The varieties range in height from 3 to 15 feet and have leaves of corresponding size.

Cosmos.—Cosmos[4] is now one of the notable fall flowers. It is a vigorous tall-growing annual, yet its bright, bold flowers have a daintiness and airiness which is heightened in effect by the feathery green foliage (fig. 16). It is most effective when planted in broad masses or along background borders against evergreens or fences at some distance from the house and the garden walks. The white, pink, and rose-colored daisylike flowers are borne in great profusion and come at a season when they are very acceptable. In the North, seed started in the house at the same time as castor-beans will give plants 3 or 4 feet in height by September. Because of the robust habit of the plant, the young seedlings should be thinned to 18 inches apart when grown on moderately good soil. Sowing the seed late and in poor soil will dwarf the plants. In the climate of Washington, D. C., of St. Louis, Mo., and farther south they perpetuate themselves by self-sown seed. These volunteer plants can be utilized for early bloom. Cosmos is especially desirable for the warmer parts of the country, where it grows and blooms luxuriantly with little care.

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[4] *Cosmos bipinnatus* Cav.

In the North only the earliest varieties are likely to mature soon enough to bloom. As the plants approach maturity it is well to give them some support, as they are liable to be bent over by the wind.

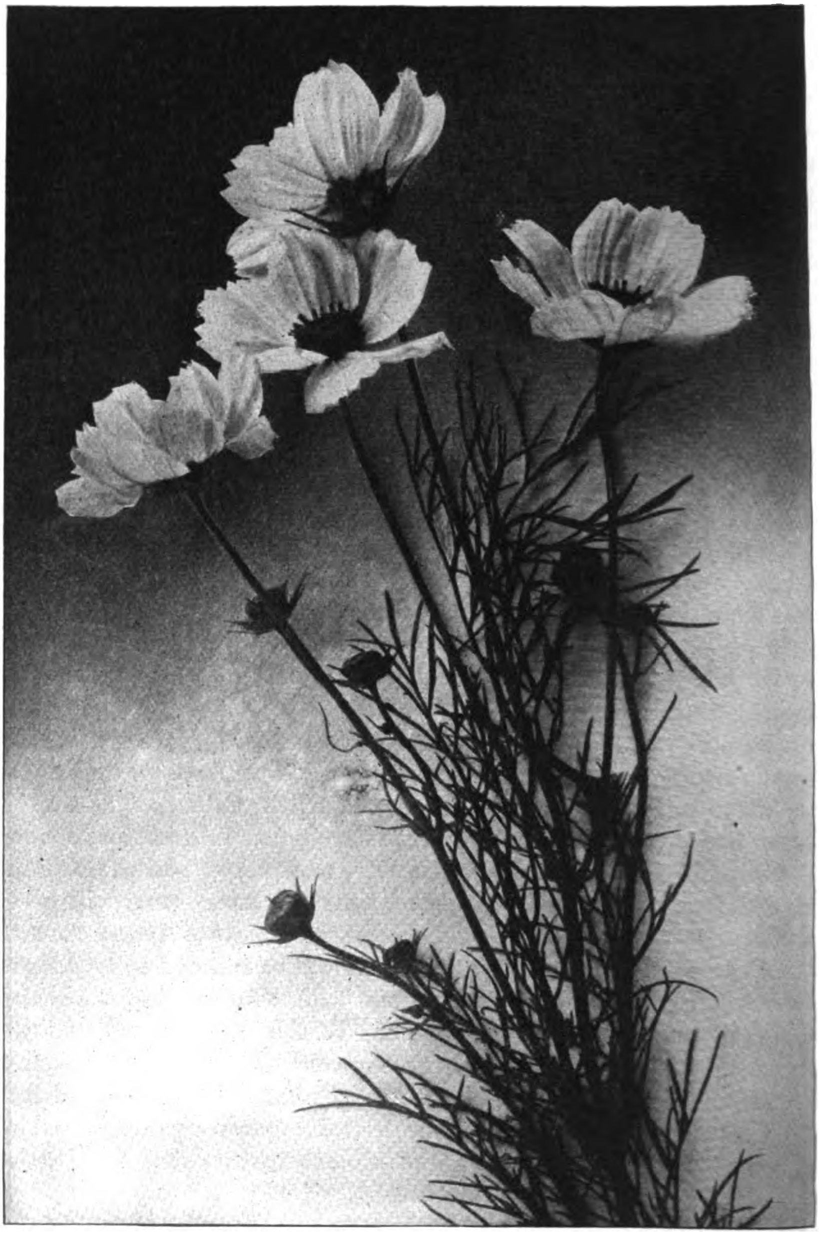

FIG. 16.—Cosmos.

Sunflower.—Sunflowers[5] are tall-growing bright-flowered annual plants that have not received the attention they deserve. They have suffered the misfortune of being cheapened by use as a burlesque. In reality, however, the tall-growing large-flowered sorts as well as the dwarf many-flowered varieties (fig. 17) are useful when skillfully employed in mixed plantations with other herbaceous annuals. The golden yellow disks are like

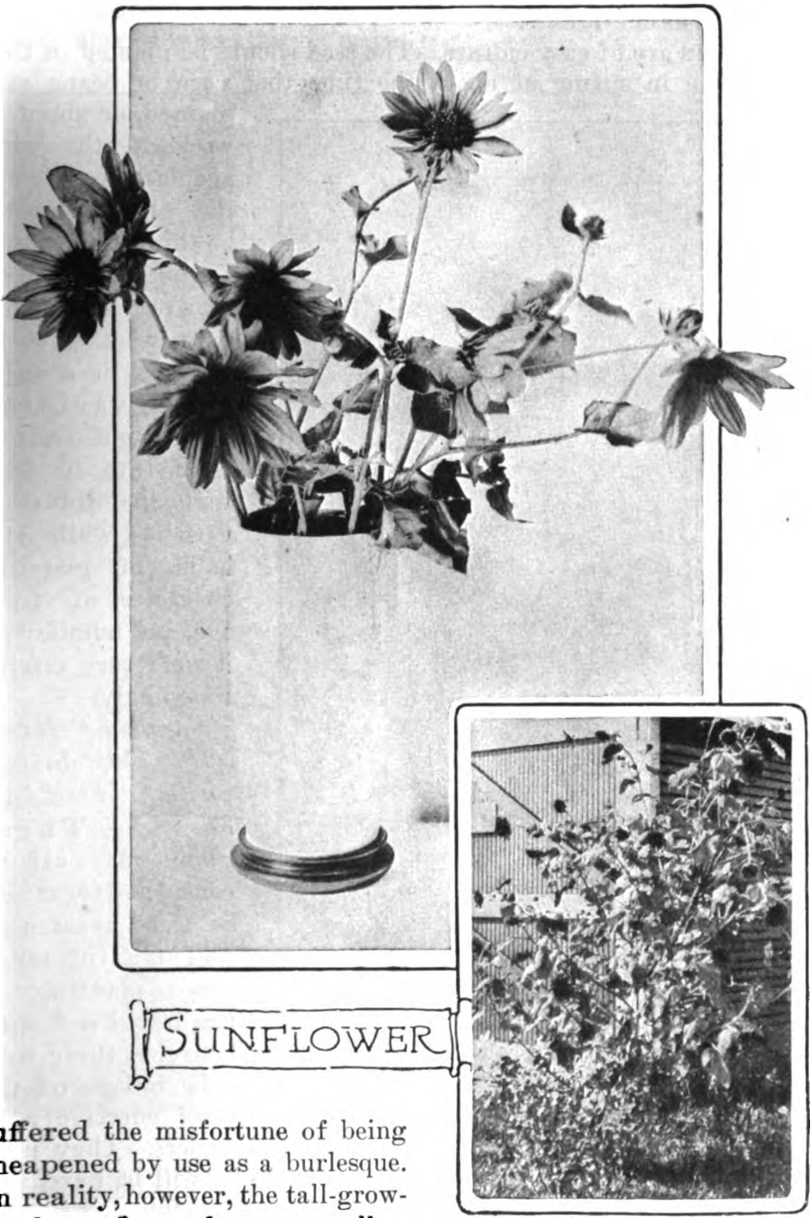

FIG. 17.

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[5] *Helianthus annuus* L. and other species.

sunbursts among the shrubbery. The tall habit and dense foliage of some varieties make them suitable for backgrounds and screens. Because of their long stems and extraordinary lasting qualities they are of value as cut flowers.

Sunflowers are of easy culture. The seed should be planted in the open garden in spring at about the time that corn or beans are planted, or about a week after the average last frost, and the plants should be thinned to stand from 2 to 4 feet apart, depending upon whether it is a dwarf or a tall-growing variety. The height ranges from 1 to 10 feet with the different varieties, while the habit of growth, character of foliage, and number of flowers vary correspondingly.

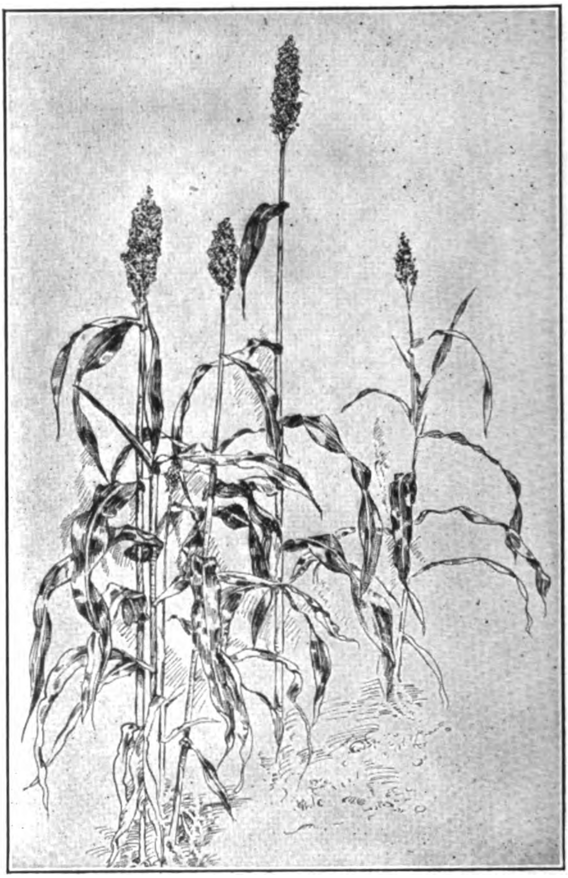

FIG. 18.—Sorghum.

Sorghum,[6] *feterita*,[6] *milo*,[6] *broom corn*,[6] *Indian corn*.[7]—**These** plants may all be considered together. as their treatment and use in landscape planting is similar. Used with castor-beans and sunflowers they may be very effective, as their foliage and habit of growth contrast strongly with the foliage of the plants already described. They may also be used effectively in clumps and groups of their own (fig. 18) or in borders. They need other plantings at their base; otherwise the stems will be bare and unsightly. They can be used effectively among thick-foliaged shrubs that have not yet grown sufficiently to take all the ground. They should be planted among plants with whose foliage they form a contrast and above which their plumelike blooms, and in some cases fruit, can show effectively.

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[6] Cultivated forms of *Holcus sorghum* L.

[7] *Zea mays* L.

Varieties vary in height from 3 to 10 feet. They are sun and warmth loving plants and should all be planted about the time Indian corn is planted, or when danger from frost is past. They are easily grown where the weather is warm.

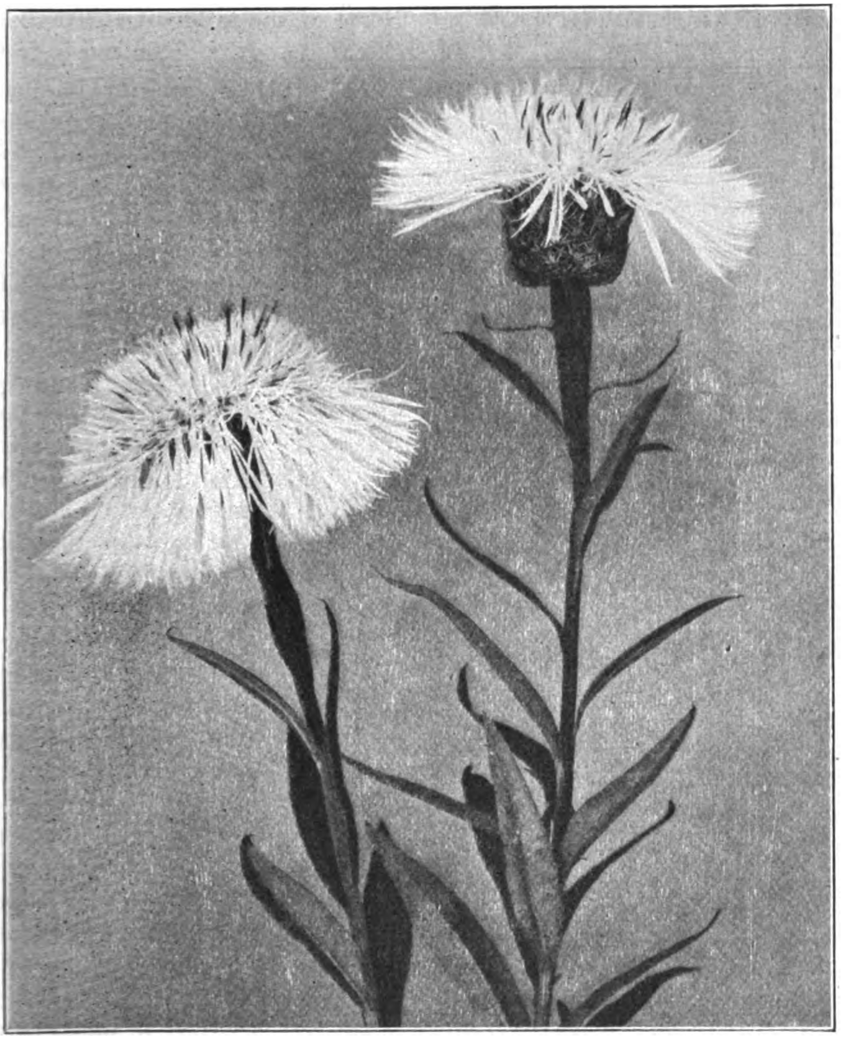

Fig. 19.—Basketflower.

In addition to the annual plants mentioned, cannas and elephant ears are vigorous-growing plants, valuable for their foliage, that are grown from roots and tubers, respectively. The first cost of these is much more than for seeds, but where a greater variety is desired they are valuable. By digging the roots before freezing weather and storing them in a cellar where the temperature is maintained well above freezing, they can be kept from year to year.

PLANTS GROWING 3 OR MORE FEET HIGH.

There are a large number of annual plants of intermediate height, many of which are very striking. Some of the taller of these that grow 3 or more feet high are the basketflower, feather cockscomb, dahlia, Joseph's-coat, larkspur, love-lies-bleeding, heliopsis, prince's-feather, sweet-sultan, spiderflower, and summer cypress.

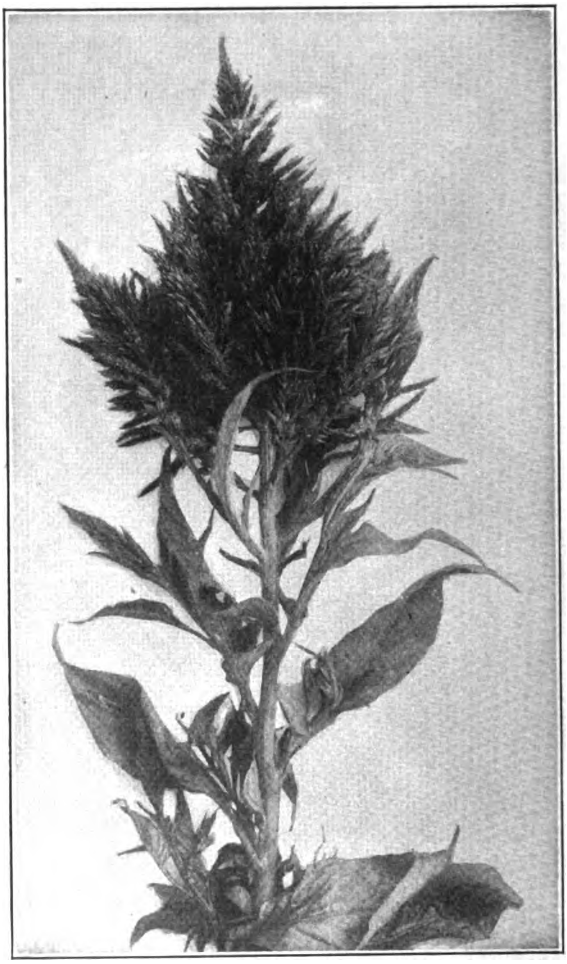

FIG. 20.—Feather cockscomb.

Of the plants already described the castor-bean, sunflower, and feterita have dwarf varieties of about this height.

Basketflower.—The basketflower[8] is a hardy native thistle-like flower (fig. 19), growing to a height of 3 feet, bearing large rosy lavender flowers. It should be sown in the open ground in early spring about as soon as the ground is in condition to work. It does well when sown where it is to bloom, but can be successfully transplanted. It prefers cool weather and is not as easy to grow as many other annuals.

Feather cockscomb.—The feather cockscomb,[9] sometimes called plumed cockscomb, but more commonly known as celosia or celosia plumosa, is a plumelike and graceful tender annual (fig. 20), growing 3 feet tall, with showy flowers, either crimson or yellow. The plumes may be cut before they are fully ripe and may be dried in the house for winter bouquets. Seeds may be sown out of doors after danger from frost is past or they may be sown earlier under glass. They prefer a light soil, not too rich, but grow easily almost anywhere.

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[8] *Centaurea americana* Nutt.

[9] *Celosia argentea* L.

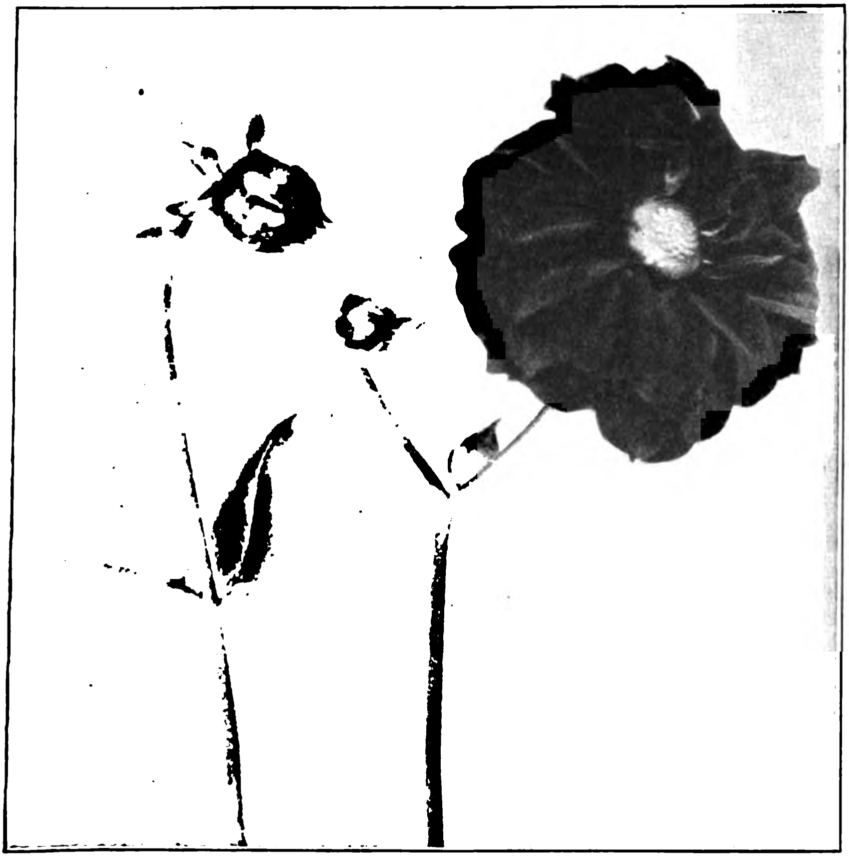

FIG. 21.—A dahlia grown from seed as an annual.

Dahlia.—The dahlia[10] has many double and some single forms in eds and yellows. They are usually grown from rootstocks, but they an be grown from seed readily by those who have had a little experinnce with plants. The double-flowered varieties must be sown as early s April for satisfactory bloom the first year, while the single varieties nay be sown as late as July 1. Dahlias (fig. 21) must be grown where frost can not reach them, so in the North it is necessary to start the double-flowered ones under glass.

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[10] *Dahlia rosea* Cav.

As soon as the tops are hurt by frost the roots should be dug on a warm sunshiny day so they will not be chilled, and then they should be stored in a warm cellar with as much dirt as possible about them. A place suitable for cannas and sweet potatoes is satisfactory for dahlias. Another method is to store them in boxes of sand. New plants may be started the next season from these roots.

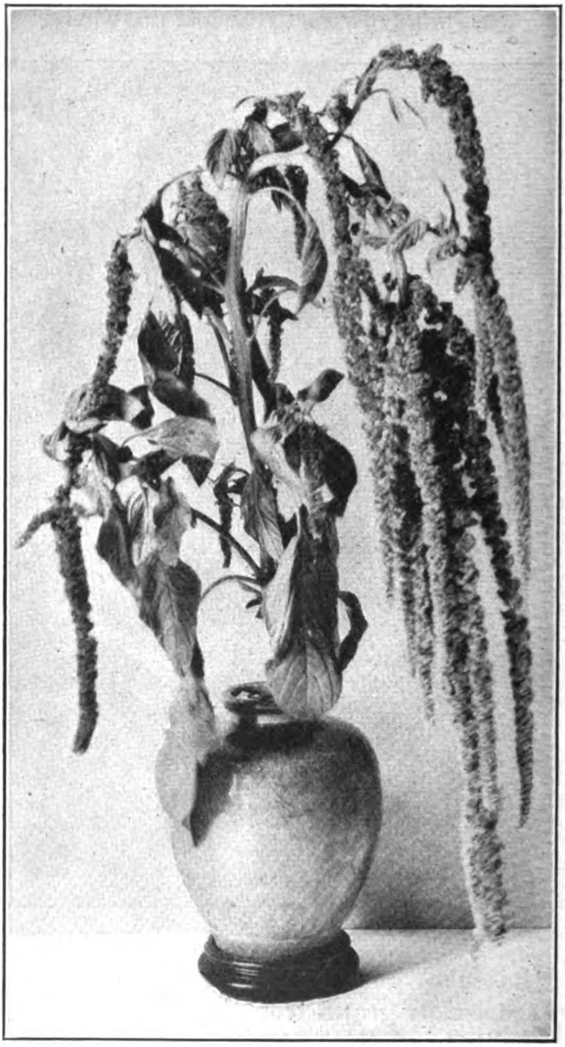

FIG. 22.—Love-lies-bleeding.

Joseph's-coat.—Joseph's-coat[11] is an easily grown upright plant reaching heights of 3 or more feet, whose attractiveness is due to the brilliant red, yellow, and green foliage. It likes warmth and sunshine and plenty of room, with the soil not too rich. It will not stand frost, so it must be started either late out of doors or under glass if results early in the season are desired. It can be started six weeks before danger of frost is past and may be transplanted once or twice before setting it in the open ground.

Love-lies-bleeding.—Love-lies-bleeding[12] (fig. 22) is another easily grown, rather upright annual with drooping blood-red foliage. It should be handled in the same manner as Joseph's-coat and responds to the same cultural conditions.

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[11] *Amaranthus gangeticus melancholicus* Voss.

[12] Amaranthus caudatus L.

Heliopsis.—Heliopsis,[13] sometimes miscalled orange sunflower, is a hardy perennial with pale orange-colored flowers that will bloom the first year from seed. It is easily grown and will attain a height of 3 to 4 feet. Seeds may be sown early out of doors about the time the last frost may be expected.

Prince's-feather.—Prince's-feather[14] is an upright annual, 3 to 4 feet tall, with dark red feathery flowers. Its culture is like that of Joseph's-coat, already discussed, and is adapted to the use of a beginner.

Sweet-sultan.—Sweet-sultans,[15] or royal sweet-sultans, are handsome sweet-scented, thistlelike, hardy annuals growing to a height of over 3 feet, with red, purple, lavender, and white varieties. They are useful both for cutting and in borders. They are sown early in the spring for the best results, so that they will get an early start and bloom before hot weather. They will stand some frost.

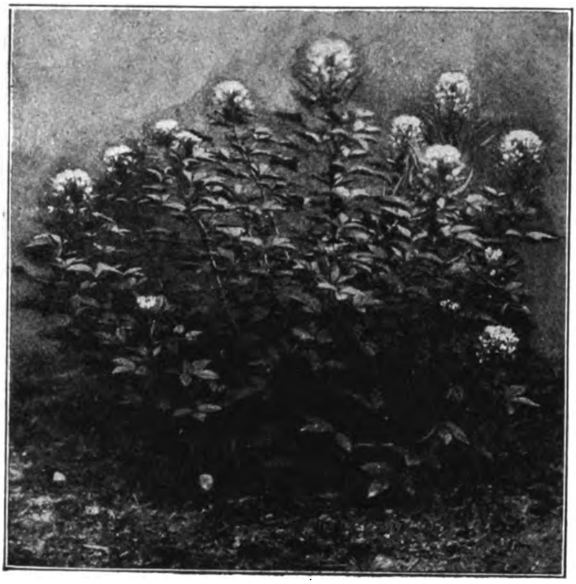

FIG. 23.—Spiderflower.

Spiderflower.—The spiderflower[16] (fig. 23) grows to a height of 3½ feet and forms large loose heads of rose-colored flowers borne well above the foliage for a long season. The seed should be sown in the open ground soon after the weather is settled, or two or three weeks before the last frost may be expected. The plant is of easy culture.

Summer cypress.—Summer cypress,[17] also called standing cypress and Mexican flame plant, is a useful plant for a pale-green mass effect or for formal effects (fig. 24). Belvedere[18] is a similar plant of more erect habit. The foliage is fine and light in color, but very effective when used in masses. When grown with plenty of room they form uniform oval symmetrical specimens 3 or more feet high. For specimen plants they should be set at least 4 feet apart; for a hedge, 18 inches or 2 feet apart. Summer cypresses do not thrive in shade, the part that is shaded failing to grow, thus making the plants one sided. On the other hand, their growth is stimulated by the close proximity of an electric arc light. As they approach maturity the whole plant gradually turns crimson, later becoming brown and unattractive on the approach of frost. The bloom is inconspicuous, but the plant seeds freely, and the second season the ground will be covered with seedlings, which, however, are readily killed by hoeing. Seed may be sown thinly in the open ground early in the spring. Culture is of the easiest.

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[13] *Heliopsis helianthoides pitcheriana* Fletcher.

[14] *Amaranthus hypochondriacus sanguineus* Hort.

[15] *Centaurea moschata* L.

[16] *Cleome spinosa* Jacq.

[17] *Kochia trichophylla* Stapf.

[18] *Kochia scoparia* Schrad.

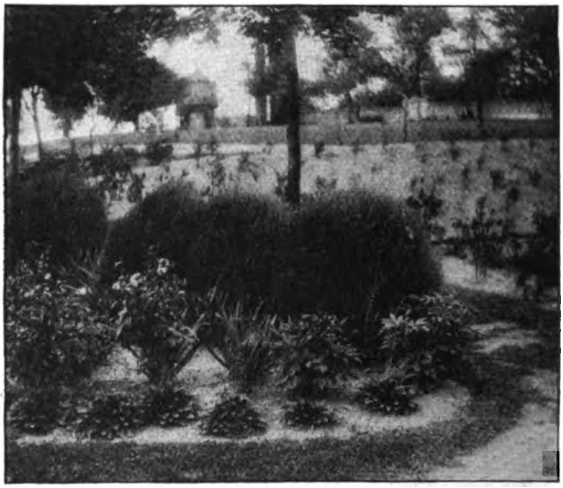

FIG. 24.—Summer cypress on the back of a bed.

PLANTS GROWING ABOUT 30 INCHES HIGH.

Plants that grow about 30 inches high are clarkia, cornflower, larkspur, scabiosa, annual poinsettia, scarlet sage, strawflower, and zinnia. Some of the varieties of sunflowers are also as small as this.

Clarkia.—Clarkia[19] is one of the prettiest of hardy native annuals. It comes to us from beyond the Rocky Mountains. Its freedom of blooming, with the variety and brightness of its white, salmon, or scarlet flowers, makes a bed of these plants an attractive sight. They are useful, too, for hanging baskets, for vases, as edging plants, for low massing, or for borders.

The seed should be sown outdoors in early spring and the plants should be grown in partial shade. The clarkias thrive in a warm light soil, and their period of bloom is from midsummer to late autumn. The average height of the plant is 2 to 2½ feet.

Cornflower.—The cornflower[20] (fig. 25) is also known as bachelor's-button, "bluebottle," "ragged-sailor," "kaiserblume," and sometimes erroneously as "ragged-robin" and "bluet." These bright-flowered plants are of a hardy nature, requiring simple culture, yet they are among the most attractive and graceful of all the old-fashioned flowers, bearing freely blue, white, or rose-colored blossoms. When placed in water after cutting, the flowers increase in size. The seeds of these annuals should be sown in the fall or in the spring from the time the ground is fit to work until the last of May in the North and the last of June in the South. They may be started earlier under glass. The young plants should be thinned to 4 to 6 inches apart. They thrive well on all moderately rich garden soils. When once established they will usually reseed themselves year after year.

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[19] *Clarkia pulchella* Pursh., *C. elegans* Douglas.

[20] *Centaurea cyanus* L.

Larkspur.—The larkspur[21] is especially valuable because of its rich blues, as blue is a comparatively rare color among our cultivated plants. There are also white varieties and a red species. The taller growing annual varieties reach a height of 30 inches and are valuable for bedding and borders as well as for cut flowers. There are other varieties only about 18 inches high (fig. 26) that are even better for bedding purposes. There are both single and double forms of the annual larkspurs. In addition to these there are many perennial varieties that will bloom the first year from seed, so they can be used as annuals with reasonable satisfaction. These vary in height from 18 inches to 5 feet. Larkspurs are easily grown, but do best in a rather cool, moist soil. The seeds of the annuals may be

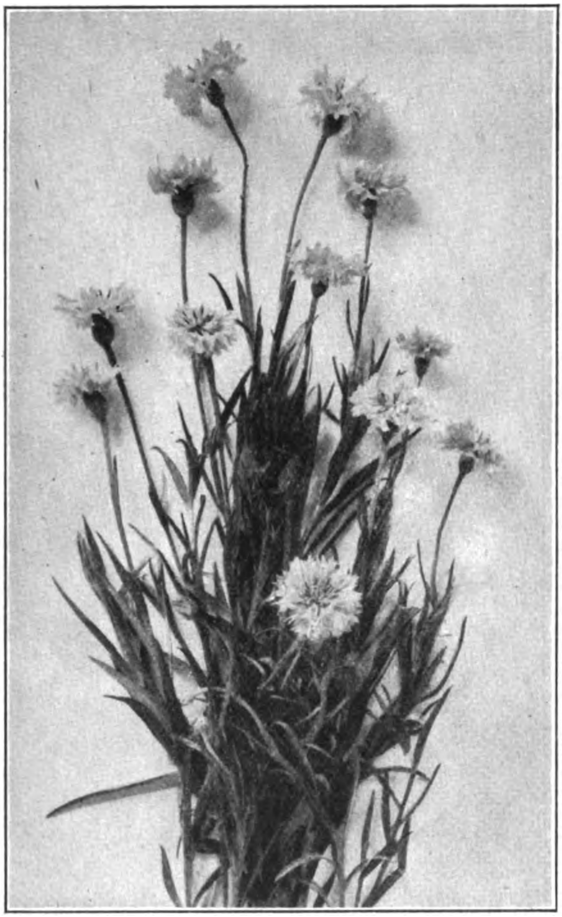

FIG. 25.—Cornflower.

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[21] *Delphinium ajacis* L., *D. consolida* L.

sown in the open ground either in late fall or in spring, preferably the former, so they will be ready to germinate early in the spring. In the South the perennial varieties may be handled in the same way. As the seedlings grow they should be thinned to stand from 6 to 18 inches apart, depending upon the variety. Among the annual larkspurs there are in addition to the blue varieties white, buff, rose, pink, and similar shades. These may all be sown separately or in mixture with entirely satisfactory results.

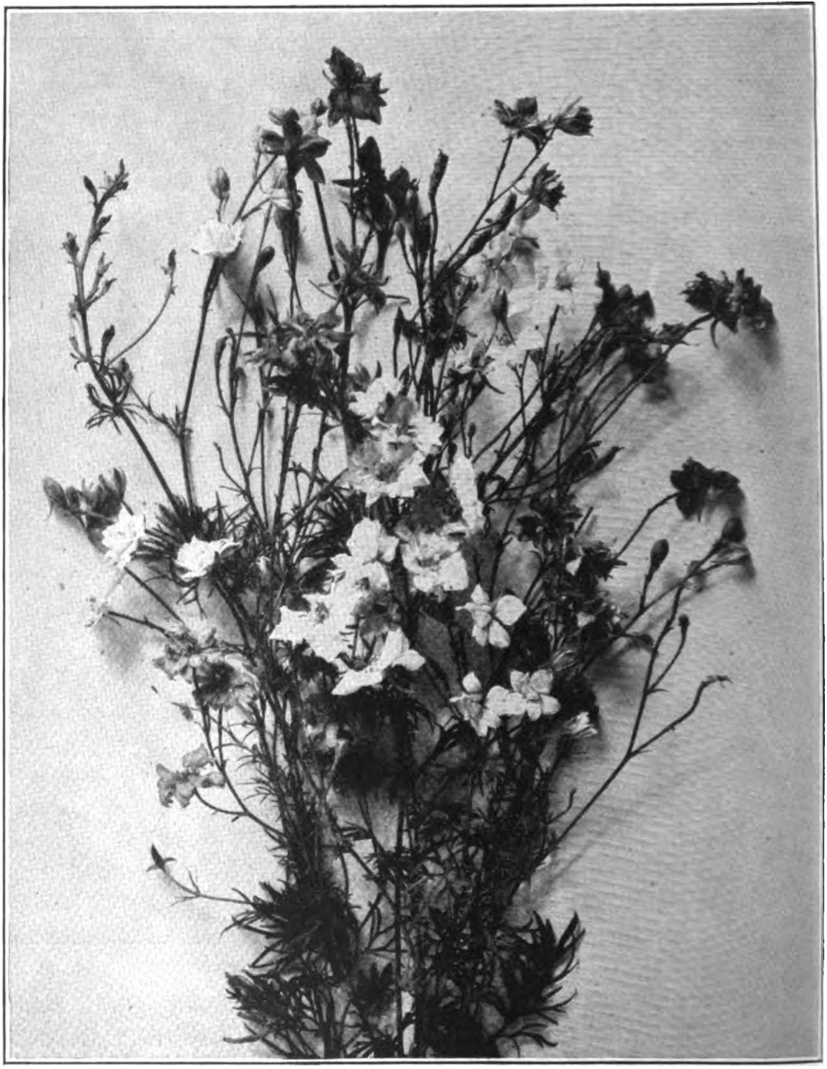

FIG. 26.—Larkspur.

From Norfolk northward the perennial varieties need to be started under glass in order to bloom the first year from seed, and the young plants can be transplanted into flats before they are an inch high, being placed 3 to 4 inches apart, and by gradually hardening them off they can be set in the open ground before corn-planting time. These plants can be set 6 to 8 inches apart the first year, but need to be farther apart the following year.

Some species bloom both early and late, and the blooming period of all can be prolonged by removing the withered flower stems promptly.

Scabiosa.—Scabiosa,[22] often called mourning bride, pincushion flower, and sweet scabious, is an easily grown old-fashioned half-hardy annual (fig. 27) that is very attractive and satisfactory both for cutting and for borders and beds. The flowers, which vary from white through rose, crimson, and blue to almost black, are borne on long stems and keep a long time either on the plant or when cut. The seed should be sown in the open ground after danger from hard frost is past and the plants will bloom in about 12 weeks. There are also hardy perennial kinds.

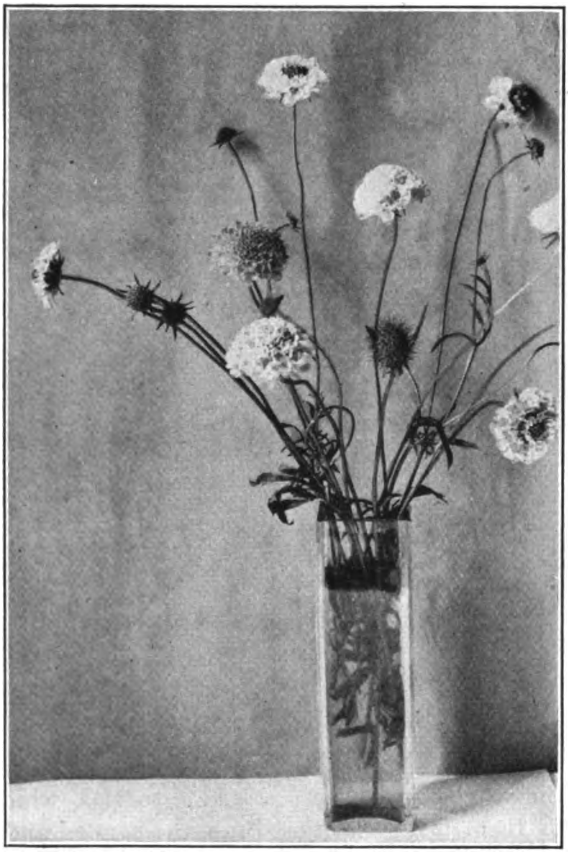

FIG. 27.—Scabiosa.

Annual poinsettia.—The annual poinsettia[23] (fig. 28), Mexican fire plant, or painted-leaf, is a handsome green-leafed plant that about midsummer changes the color of several of the leaves at the ends of the branches to scarlet. As the plant is naturally much branched and bushy, it makes a great show. It attains a height of 2 to 3 feet. Seed should be sown in the open ground when freezing weather is past.

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[22] *Scabiosa atropurpurea* L.

[23] *Euphorbia heterophylla* L.

Scarlet sage.—The scarlet sage,[24] or scarlet salvia, is a standard bedding plant that keeps the garden bright with color until late in autumn. This plant lends itself to many uses (fig. 29); it makes a good pot plant, does well in window boxes, and is useful for cutting, to give color. Its commonest use, however, is as a hedge or border plant, giving long broad bands of vivid scarlet. On account of its very striking color, caution needs to be observed in using it in this way. It can be most effectively used in small clumps among or against masses of green.

Seeds should be sown in window boxes or frames six weeks before the last frost and the plants set outdoors after all danger from frost is past. Or the seeds may be sown outdoors, if the place is protected from heavy rains and strong winds, about the date of the last frost, so the seed will not germinate until after all danger of frost is over. The plants grow and bloom profusely in any light rich soil. Besides the scarlet sage, there are blue salvias, which are perennials, most of them being hardy. Both the tender and hardy perennial sorts bloom the first year, and all may be treated as annuals.

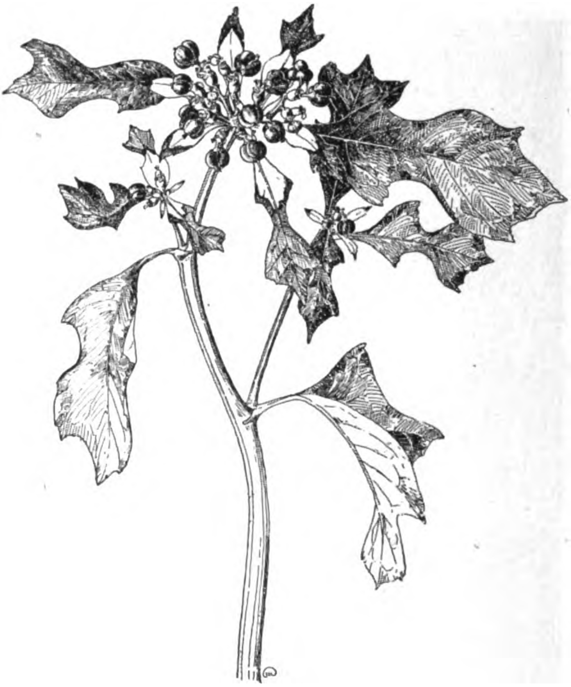

FIG. 28.—Annual poinsettia.

The strawflower.—The strawflower[25] is an attractive, easily grown, hardy annual, bearing double lemon and yellow flowers an inch and a half across (fig. 30). These plants are very effective for beds and borders, and the flowers may be cut and dried for winter bouquets. They succeed in any good garden soil, but respond to plenty of fertility. The seed may be sown in the open ground as soon as all danger of freezing is past. They do better, however, if transplanted once or twice. They should have plenty of room to develop, not

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[24] *Salvia splendens* Ker.

[25] *Elichrysum bracteatum* Andr. (Helichrysum).

SCARLET SAGE

being planted closer than 12 inches apart. They grow to a height of 30 inches.

Zinnia.—The zinnia,[26] sometimes called youth-and-old-age, is easily grown from seed sown in the open ground. When sown as soon as the ground is fit to work, the plants will bloom abundantly and continuously through the entire season (fig. 31). Of late great improvements have

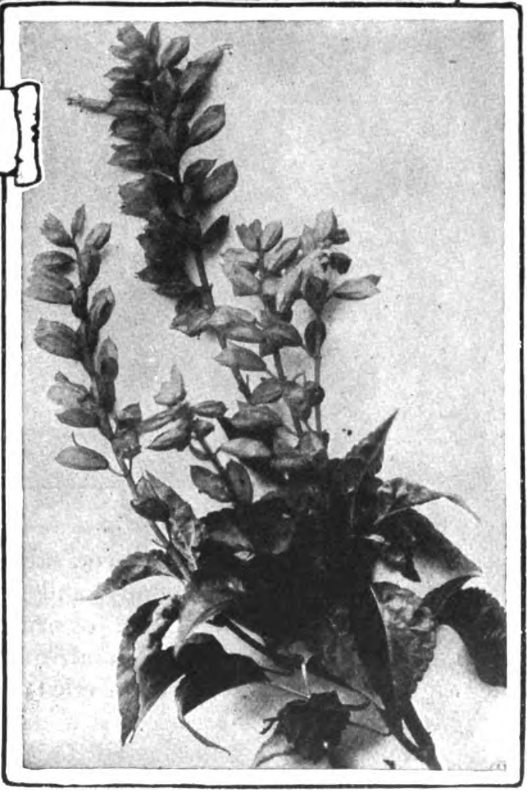

FIG. 29.

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[26] *Zinnia elegans* Jacq.

been wrought both in the color and form of the flower. Their colors are white, yellow, orange, pink, rose, and scarlet. During the month of August zinnias are at their best. To secure large flowers and a profusion of bloom the plants must be given ample room for full development as well as an abundant supply of food. Strong rich soils suit them. If the seeds are sown in a dwelling house or in a hotbed and the young plants are pricked out once or twice before being placed in their permanent situations more satisfactory results will be secured than from outdoor-sown seeds, unless equal care in thinning or transplanting is given. The plants can be used for groups, beds, borders, garden lines, and summer hedges. Their average height is 2½ feet, ranging from 2 to 3 feet.

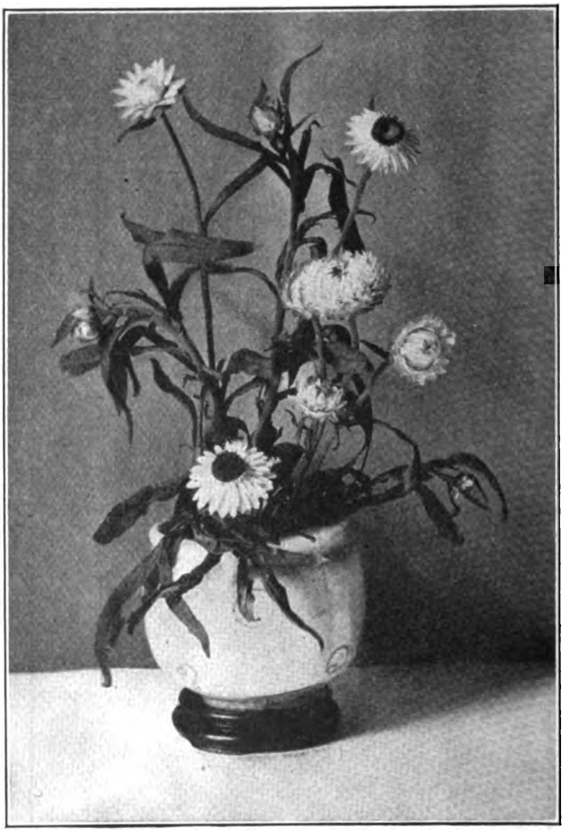

FIG. 30.—Strawflower.

PLANTS GROWING ABOUT 24 INCHES HIGH.

Several of the annual flowering plants that grow about 2 feet high are very useful both for ornamental planting and cut flowers. Among these are baby's-breath, calliopsis, China aster, summer chrysanthemum, cockscomb, rudbeckia, gaillardia, lupine, African marigold, Japanese bellflower, salpiglossis, and snapdragon. The garden balsam, Shirley poppy, and snow-on-the-mountain are other plants of this height desirable for ornamental plantings but not suitable for cutting. Of the plants already discussed the larkspur, scarlet sage, and sunflower have varieties that are about this height.

Baby's-breath.—Baby's-breath[27] is a dainty free-growing white-flowered plant that is much used to put with cut flowers, to

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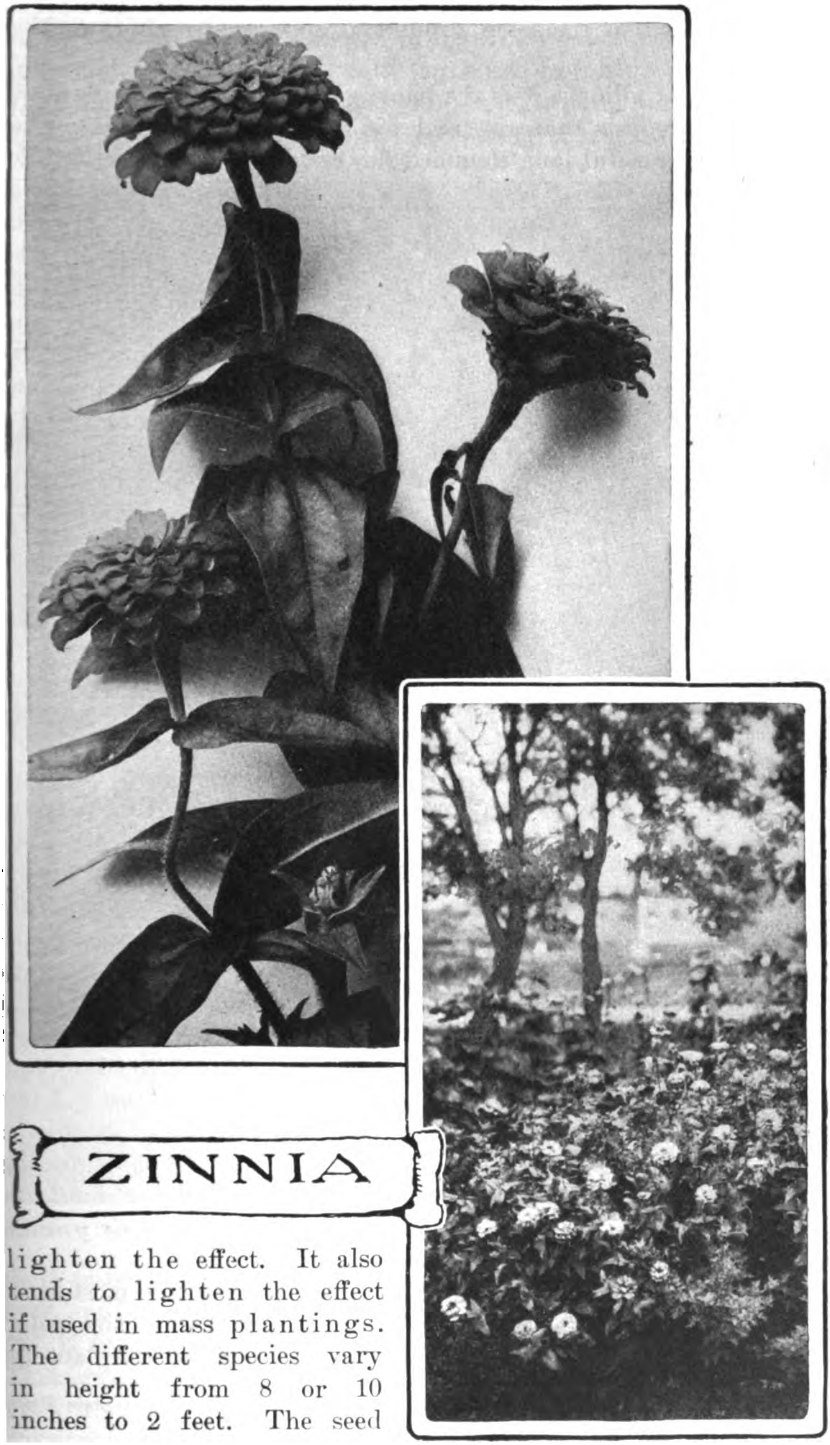
[27] *Gypsophila elegans* Bieb. and *G. muralis* L., annuals, and *G. paniculata* L., a perennial.



ZINNIA

lighten the effect. It also tends to lighten the effect if used in mass plantings. The different species vary in height from 8 or 10 inches to 2 feet. The seed

Fig. 31.

should be sown in the open ground as soon as freezing weather is well past.

Calliopsis.—Calliopsis[28] is the name given to the annual plants of the genus Coreopsis that are used for ornamental planting. They have showy, graceful long-stemmed flowers (fig. 32) well suited for bouquets and yet so borne as to make very effective border or bedding plants. The principal color is a deep yellow, which is combined in some varieties with rich maroons and in others with browns. Varieties vary in height from 9 inches to 2 feet. They are of the easiest culture.

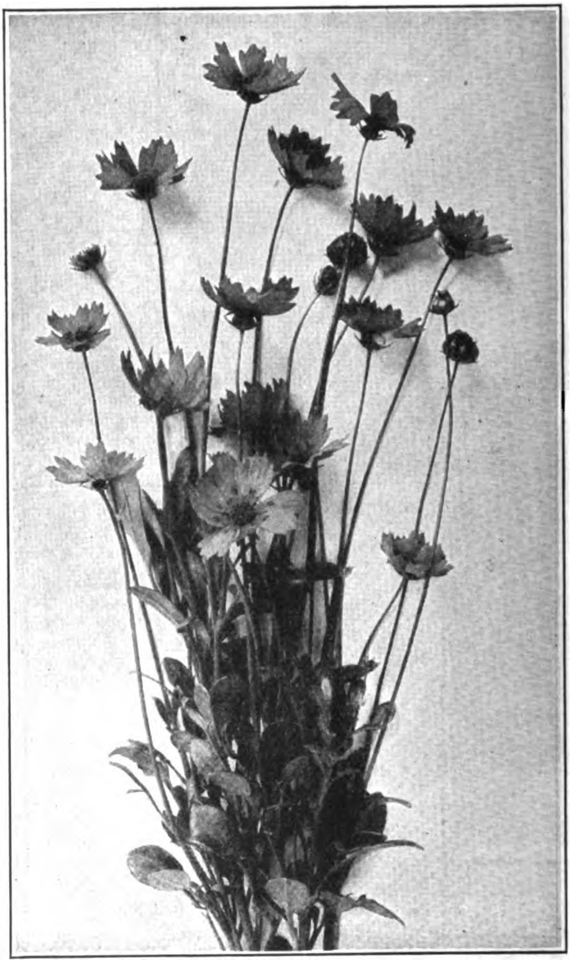


FIG. 32.—Calliopsis.

Seeds may be sown under glass or in the open, but they should not be sown outdoors before the date of the last frost. They may be sown under glass two months before this. Seeds sown in the open in May will usually give an abundance of flowers from August till frost. After transplanting or their final thinning the plants should be 10 inches apart each way. The perennial form, *Coreopsis grandiflora*, will bloom the first year if the seed is sown early.

China aster.—The China aster[29] is certainly one of the most satisfactory of the annual flowering plants. The variety in its size, color, form, and season of blooming makes it a most satisfactory plant for supplying cut flowers; in fact, many of the improved sorts produce flowers equal in form and size to some of the better sorts of chrysanthemums. The range of color presented in this group is one of its chief merits. Strange as it may appear, the plant world is not very well supplied with blue flowers possessing characters which render them suited to domestic or commercial uses. In the China aster, however, are found many shades of lavender and purple, and for this reason, if for no other, they should prove an attractive decorative plant. There are also white, pink, and rose-colored varieties. The habit of growth adapts the China aster to close planting for cut bloom, for window boxes (fig. 33), and also for bedding. It should not be con-

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[28] *Coreopsis tinctoria* Nutt., *C. basalis* Blake (*C. drummondii*), *C. nuecensis* Heller (*C. coronata*).

[29] *Callistemma chinensis* Skeels (*Callistephus chinensis*).

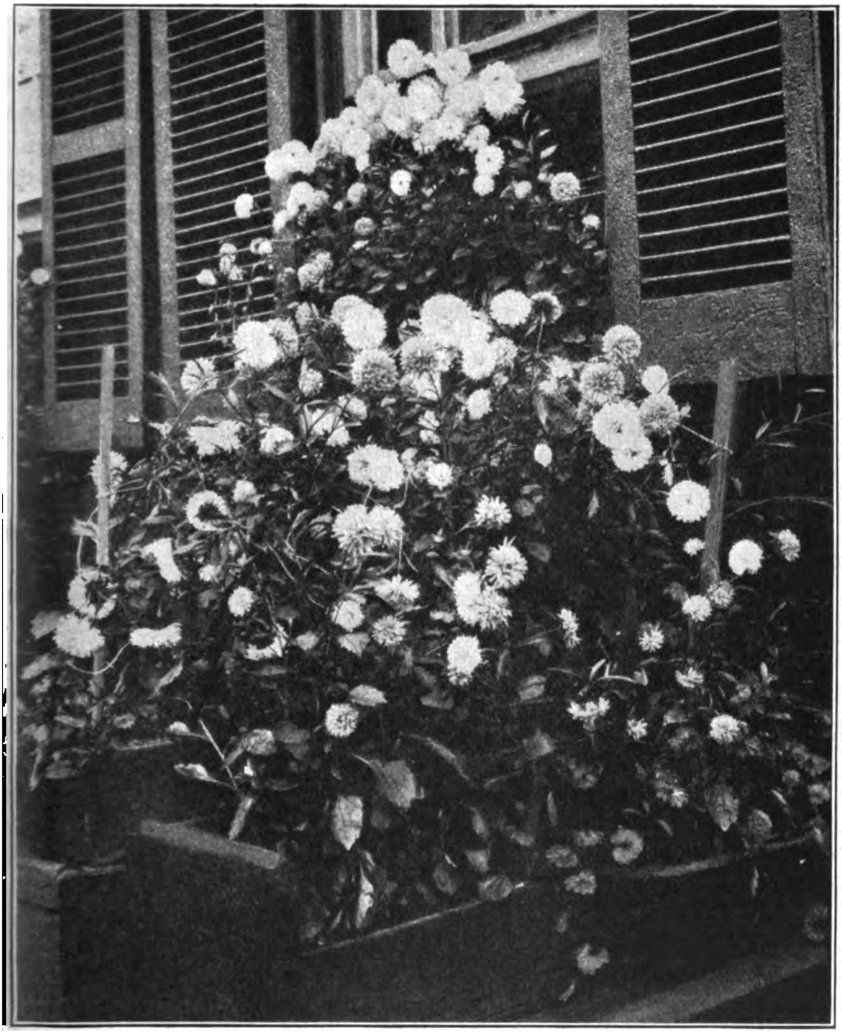

FIG. 33.—China asters in window boxes.

fused with the attractive native hardy perennial asters, which are robust tall-growing plants well adapted for use in an herbaceous border where late bloom and careless effects are desired. The more compact-growing large-flowered China asters are most desirable for cut blooms, while the tall-growing open wild aster[30] is most useful in wild gardens or for screens. The vigor and ease of culture of the China aster are factors which contribute to its popularity.

Plants from seed sown in the open ground in May and supplied sufficient moisture bloom abundantly in September and October, when the flowers are seen at their best. For July and August blooms the seeds should be sown in March or April. When frosts occur during this season the planting will need to be done in a coldframe, a spent hotbed, or in pots or boxes in a living room. Cover the seed about half an inch deep with rich light soil, and when the plants have three or four leaves transfer them to thumb pots or to other boxes, setting the plants about 2 inches apart each way. After all danger of frost is past transplant the plants so treated to their permanent home, where they should stand about 18 inches apart each way in well-prepared beds. Fresh manure or manure used in too large quantities sometimes proves injurious to them. Only thoroughly composted manure mixed with the soil is safe for these plants. Small quantities of air-slaked lime or of fresh wood ashes stirred into the surface of the beds are beneficial. When given plenty of water and rich, fine soil China asters can be grown into beautiful pot plants.

In some localities and during some seasons the China aster is seriously attacked by the so-called black potato beetle, or blister beetle,[31] an insect which feeds upon the partly developed buds, causing them to develop, if at all, into deformed, irregular blossoms. In such localities these flowers can be successfully grown under screens of mosquito netting or other thin cloth.

Chrysanthemums.—The chrysanthemums, like the pinks, comprise some of the most valuable of the commercial florists' products, both hardy perennial and annual flowering plants. The large-flowered types of chrysanthemums, which each autumn produce such gorgeous shows in the stores, florists' establishments, and conservatories, are not hardy, and since they are treated as greenhouse plants by the florists, they are only mentioned in this list. The class of hardy chrysanthemums, which should be more commonly seen in every flower garden and are known as pompons, are simply noted to give proper relation to the annual chrysanthemums, which are the subject of this sketch.

Summer, or annual, chrysanthemums[32] bloom most satisfactorily if the seeds are sown early in a hotbed or coldframe and the young plants transferred to the open as soon as the soil has become sufficiently warm to keep them growing without check, or two weeks after the usual date for the last frost. If started in a hotbed the young plants should stand 10 to 12 inches apart when set in their permanent locations. Somewhat less satisfactory results can be secured by sowing the seed in the open where the plants are to bloom at or just before the date of the last frost. The seedlings should be thinned to stand at least 8 inches apart. If the same care in regard to disbudding and pinching back is taken with the annual plants as with the large-flowered perennials, the work will be rewarded by the greatly increased size of the usually white or yellow flowers. (Fig. 34.)

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[30] *Aster novae-angliae* L.

[31] *Epicauta pennsylvanica.*

[32] *Chrysanthemum carinatum* Schousb., *C. segetum* L., *C. coronarium* L.

The hardy chrysanthemums[33] will bloom a little the first year from seed if started early, but the plants will not be compact and bushy until the second year. They should be started early in March, and where freezing is liable to occur after planting they should be started under glass in order to give them time to mature before frost.

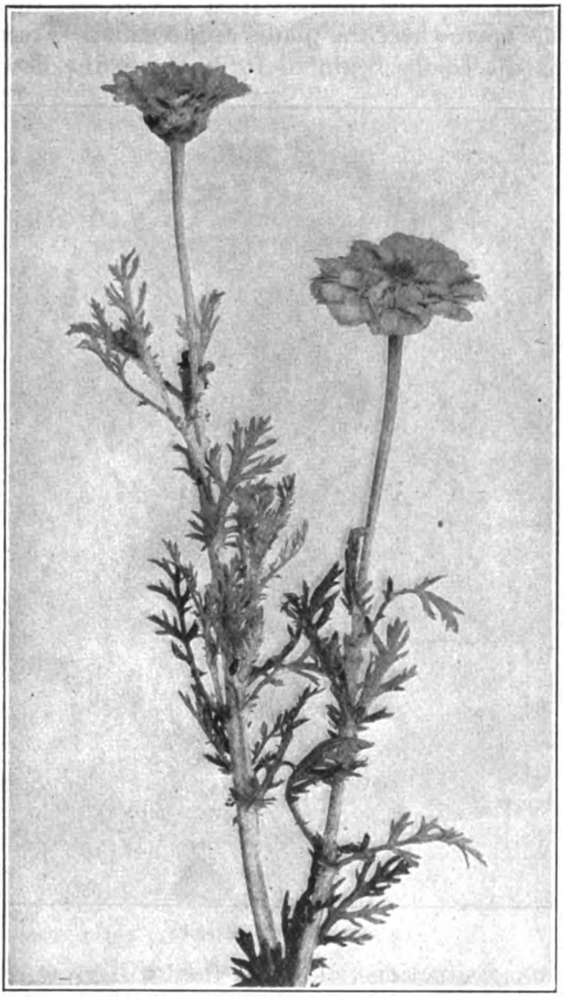

FIG. 34.—Summer chrysanthemum.

Cockscomb.—Cockscombs[34] are prized and planted as an easily grown odd and picturesque decorative feature of the garden (fig. 35). The tall ones form striking groups, and when interspersed with other lower growing plants in a border they produce a pleasing contrast, while the dwarf varieties make novel and attractive borders. There are bright red and crimson varieties. The young plants can be grown from seeds sown in gentle heat four weeks before the last frost and transplanted to the open ground when danger of frost is past, or about the time the last frost is expected the seeds may be sown in the open where the plants are to stand. Transplanting into rich soil as the combs begin to form makes the flower heads much larger. They are bright from midsummer until frost.

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[33] *Chrysanthemum leucanthemum* L.

[34] *Celosia cristata* L.

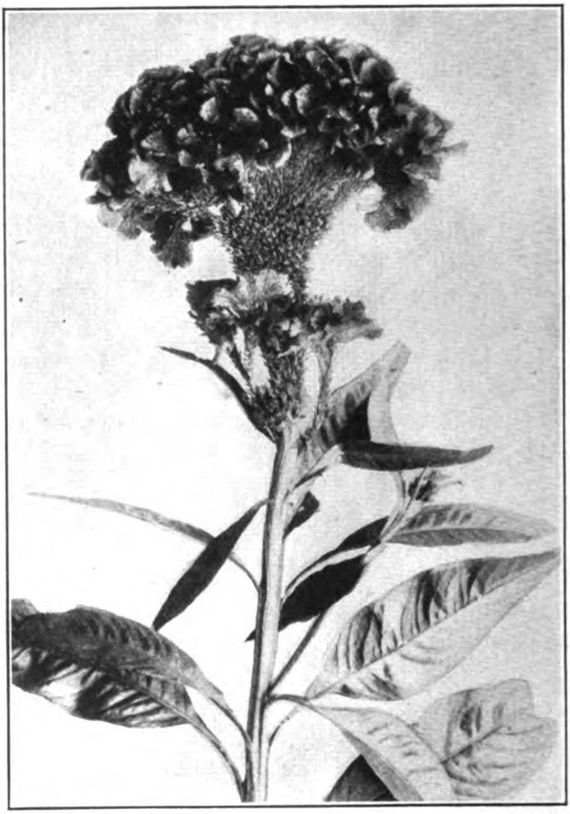
Fig. 35.—Cockscomb.

Rudbeckia.—The rudbeckias, sometimes called coneflowers, are principally perennials, but there is one annual[35] that grows about 2 feet high and bears handsome yellow flowers with a brown center (fig. 36). Not only is the disk brown, but the bases of the ray flowers as well. The seed may be sown in the open ground as soon as freezing weather is past, or for earlier bloom it may be sown under glass. The plants respond to plenty of manure, and they like warm, sunny situations, although they will grow readily almost anywhere.

The hardy perennial rudbeckias[36] may be treated as annuals. The flowers are quite showy and usually have yellow rays, though some are crimson and others more or less covered with brown toward the base. The rudbeckias are very easy of cultivation, thriving in almost any soil and climate. Most of them prefer a moist soil, but will thrive in the garden under ordinary cultivation.

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[35] *Rudbeckia bicolor* Nutt.

[36] *Rudbeckia hirta* L., *R. triloba* L.

The blackeyed-susan (*Rudbeckia hirta*), or "niggerhead" as it is sometimes called, will thrive in the hottest and driest situations. *Rudbeckia triloba*, a biennial, perpetuates itself through self-sown seeds. It may be used quite effectively as a border to a large bed of delphiniums or as a screen, as it forms a dense bush between 3 and 4 feet high. The rudbeckias are propagated from seeds or cuttings or by division. They are easily handled. When grown from seeds they may be sown in the open ground as soon as it is dry enough to work after freezing weather, or earlier with heat. The golden glow,[37] one of the most satisfactory hardy perennials, is well adapted for planting in a shrubbery or herbaceous border. It is propagated by division of the roots. It grows to a height ranging from 3 to 6 feet and may be used as a screen when lower growing plants are placed in the foreground.

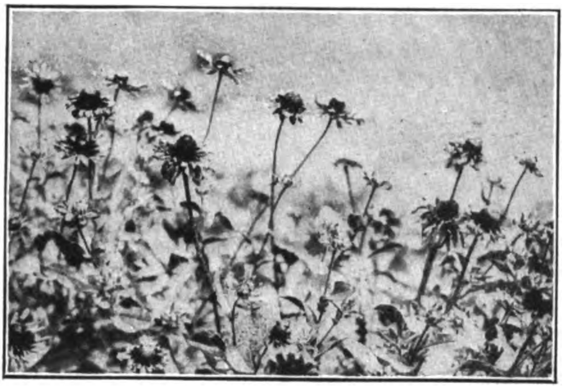
FIG. 36.—Rudbeckia.

Gaillardia.—In the gaillardias,[38] or blanketflowers, are found both annual and perennial plants of easiest culture, offering a wide selection of varieties and a profusion of bloom over a long period. The blooming period begins early and continues late in the autumn. These are plants well adapted to mixed borders (fig. 37) and are very satisfactory as cut flowers. The stems are of good length, carrying the orange and crimson flowers well, while the cut flowers keep fresh for a long time when placed in water.

The annual gaillardias are all propagated readily from seeds sown where they are to grow soon after freezing weather is past, although they can be started under glass and be transplanted to their permanent location as soon as killing frosts have passed. In either case, the blooming plants should not stand closer together than 10 to 12 inches. They grow and bloom best when fully exposed to sun and air and when planted on a fertile but light and well-drained soil.

Lupines.—Lupines[39] (fig. 38) are blue-flowered hardy annuals of easy culture that succeed in partial shade. They grow about 2 feet high and are useful in mixed borders, in beds, and for cutting. They should be sown in the open ground as soon as the soil is fit to work, or earlier under glass.

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[37] A double-flowered form of *Rudbeckia laciniata* L.

[38] *Gaillardia pulchella picta* Gray.

[39] *Lupinus*, several species.

African marigold.—The African, or Aztec, marigold[40] is the taller of the two distinct types of garden marigolds, each with numerous horticultural varieties. Each type is derived from a different species. They are popularly spoken of as African marigold and French marigold, but their common names give no clew to their nativity. The former is not only the taller, but is more spreading in growth, and is well adapted to herbaceous or shrubbery borders. It frequently grows 2 or more feet in height, and for this reason it is better suited for planting in mixed borders or along belts of trees and shrubs than in beds or massed in small areas. This is the common marigold of the garden in America (fig. 39). The leaves and flowers are strong scented, while the range of color is from sulphur yellow to orange, the darker shades being more commonly met with than the lighter ones.

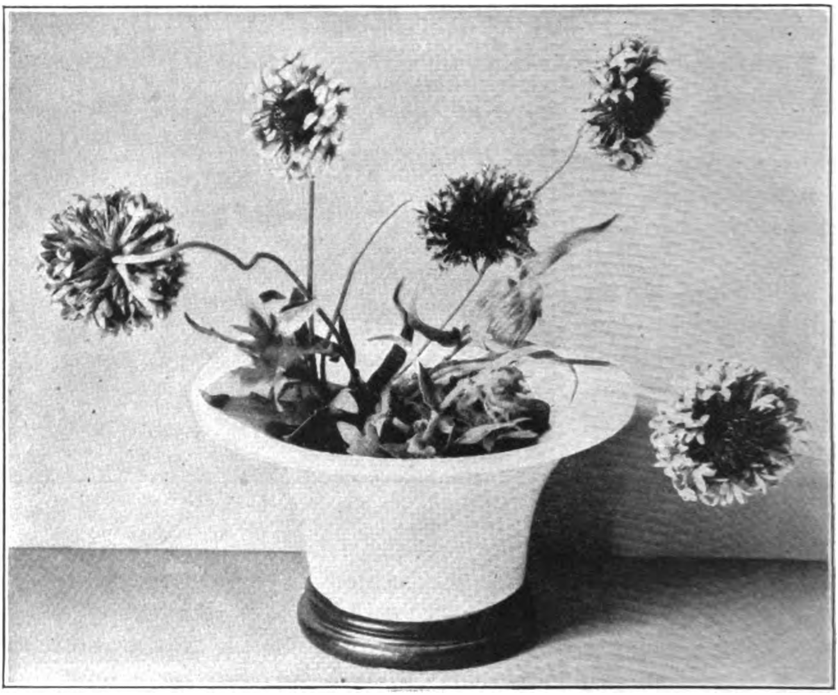

FIG. 37.—Gaillardia.

These plants may be started under glass or in the open ground as soon as freezing weather is past. They are of easiest culture.

Japanese bellflowers.—The platycodons, balloonflowers, or Japanese or Chinese bellflowers,[41] are blue and white flowered hardy perennials, which succeed fairly well as annuals. The seed may be sown as soon as freezing weather is past, and the plants will begin to bloom in about four months. They will thrive in any good garden soil, but are not as readily grown as many of the true annuals.

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[40] *Tagetes erecta* L.

[41] *Platycodon grandiflorum* A. DC. and *P. grandiflorum japonicum* Stubenrauch.

Salpiglossis.—The salpiglossis,[42] or painted-tongue, is an unusually dainty and attractive funnel-shaped flower ranging from white to purple and crimson, more or less veined with gold, and borne on slender upright stems that give the whole plant an air of distinction (fig. 40). The seed should be sown early under glass or in the open ground as soon as danger of frost is past. It is not suited to bedding, but is beautiful in the border or for cutting. It is a little more difficult to grow than some of the other annuals.

Snapdragon.—The snapdragon[43] is a valuable border plant. It is a perennial, but flowers the first year from seed sown in the spring. The bright color and peculiar form of the flowers (fig. 41) always attract attention. The newer sorts offer an enlarged variety of colors and of markings ranging from white to yellow and scarlet. The spikes are useful for cutting, keeping fresh a long time. From seed sown in the open ground when danger of frost is past blooms will be obtained in about 10 weeks. For early flowers the seed should be sown under glass and transplanted into beds of

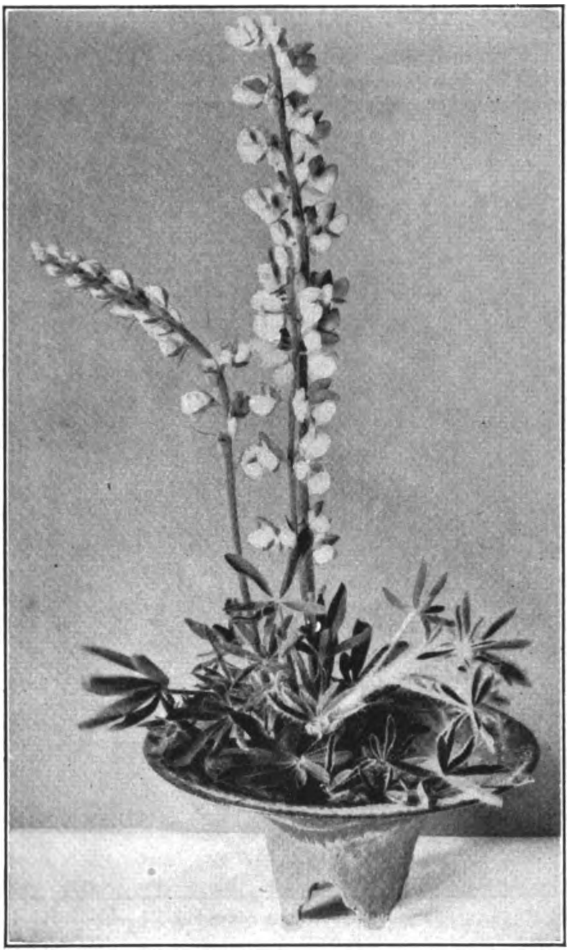

FIG. 38.—Lupine.

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[42] *Salpiglossis sinuata* Ruiz and Pav.

[43] *Antirrhinum majus* L.

warm, dry soil moderately enriched. If protected by a coldframe or even a mulch of leaves in the North, the plants will winter well and bloom early the following year. The snapdragon, like most perennials and biennials which bloom the first year and of which a particular display is desired, should be treated as an annual and sown every year. The plant is of easy culture and blooms freely and continuously until frost.

Balsam.—The garden balsam[44] is a native of India. It likes hot sun, rich soil, and plenty of water. The young plants are quick, sure growers, and seeds sown in the open ground about the time of the last frost soon form handsome bushes thickly massed with large roselike white, pink, or rose-colored flowers (fig. 42). Transplanting two or three times has a tendency to dwarf the plants into better shape and and to make the flowers more double. Balsams are not often given room to perfect their development; they will easily cover from 12 to 18 inches of space each way. For the finest flowers choice seed is more than usually essential, as cultivation and selection have wrought wonders with this plant. The one objection to the balsam is its habit of producing its flowers on the under side of the leaves or inside the plant as it were. While the individual flowers are beautiful, the obscure manner in which they are borne detracts considerably from their ornamental value. When used at the margin of groups or to crown a terrace bank they are shown to best advantage.

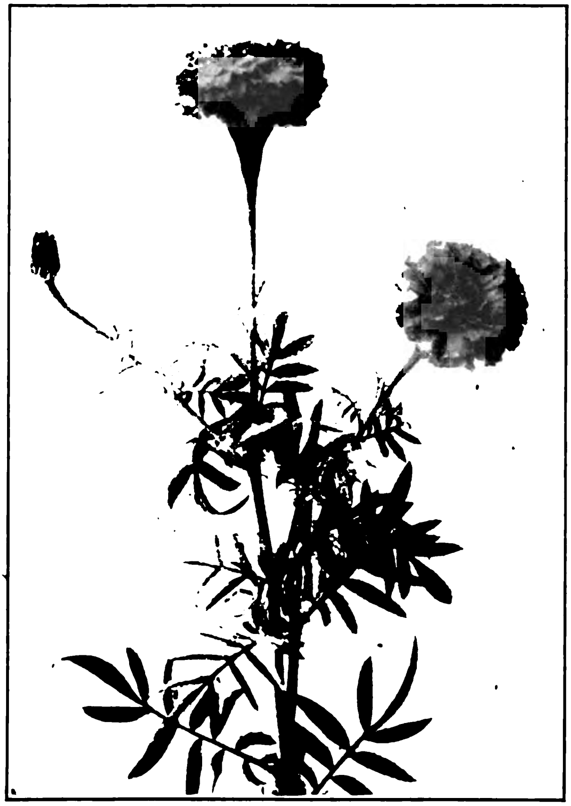

FIG. 39.—African marigold.

For early blooms balsam seeds should be sown in a gentle hotbed or in a dwelling house about eight weeks before the last frost. As soon as the first true leaves have developed, the young plants should be transplanted to thumb pots or to boxes, where they will stand about 2 inches apart each way. An abundance of light and water is at all times necessary for success with these plants. Care should be exercised to prevent them from becoming drawn, as stocky, symmetrical plants produce the best flowers. They should be transplanted to the open when the weather has become warm, as they will not stand frost.

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[44] *Impatiens balsamina* L.

Poppy.—In the spring, even before tulips are fairly gone, old gardens begin to be gay with poppies.[45] No other plants possess so bold and brilliant a flower, coupled with the same grace of stem, airiness of poise, and delicacy of tissue. For beds and borders, with a background of green, there is nothing which will produce a more striking contrast than their white, pink, or scarlet flowers. Some sorts are admirable for naturalizing in open wooded grounds; others, like the beautiful Shirley poppy,[46] may be used for cutting, though these last only a few hours. A sandy loam suits poppies best. As their strong taproots are difficult to transplant, it is well to sow the seed where the plants are to bloom. Sowing seed just before winter and at intervals in the spring, the first sowing being while the ground still freezes at night, will provide a long succession of flowers. The seeds should be sown thinly and covered very lightly, as they are quite small. As soon as the young seedlings are well established the plants should be thinned to stand about a foot apart. The plants which bloom most profusely are those grown from fall or early spring sowings while the earth is cool and moist. They may be sown as

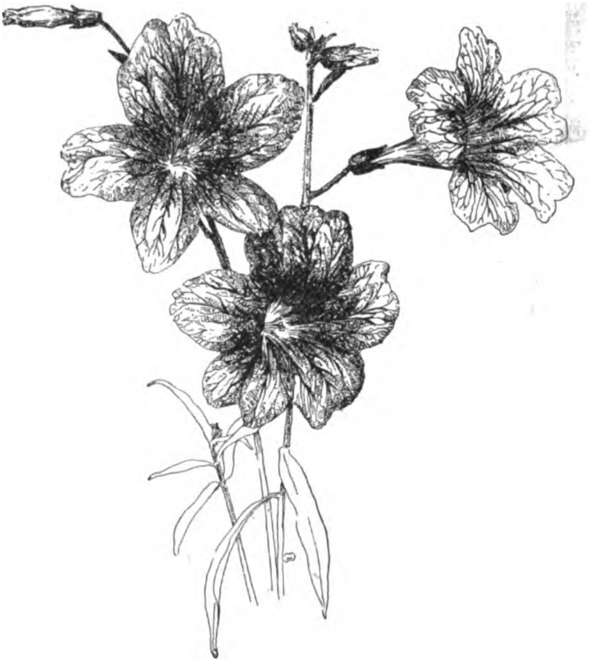

Fig. 40.—Salpiglossis.

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[45] *Papaver*, several species.

[46] *Papaver rhoeas* L.

early as the soil can be worked. They are well adapted to the use of the beginner.

Snow-on-the-mountain.—Snow-on-the-mountain[47] is a strong-growing hardy annual foliage plant whose attraction lies in the white borders to the bright green leaves (fig. 43). It is very showy in mass, but needs a facing of other plants, as it is apt to form a broad head with few branches near the ground. Its flowers are inconspicuous.

The seeds of snow-on-the-mountain should be sown in the open ground when freezing weather is past, or earlier under glass. The plant is easily handled and will grow in almost any soil, but it makes the greatest growth where there is plenty of fertility and is the most showy on poor ground. It frequently reseeds itself.

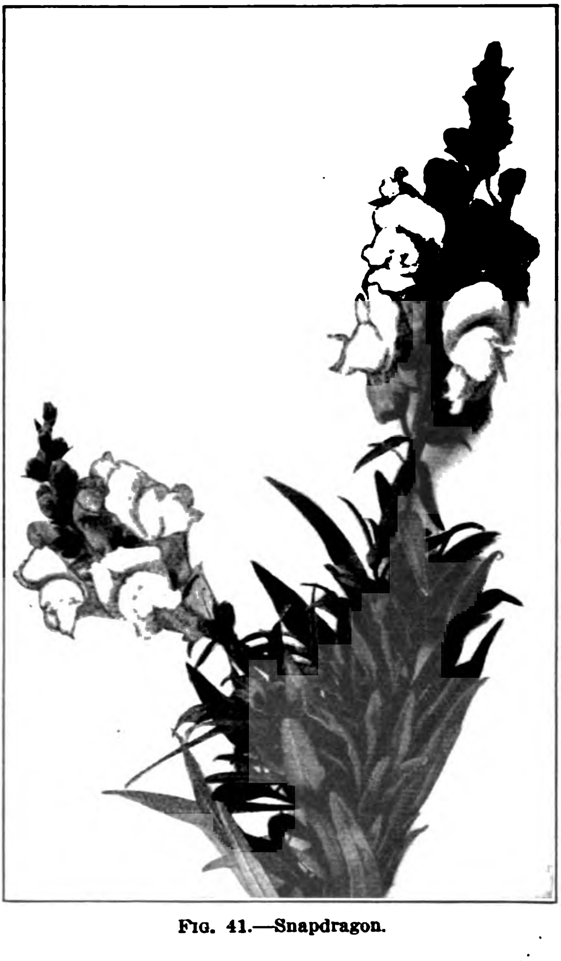

FIG. 41.—Snapdragon.

PLANTS GROWING ABOUT 18 INCHES HIGH.

Plants that grow about 18 inches high are the globe amaranth, four-o'clock, godetia, Job's-tears, mignonette, rose everlasting, and stock.

Four-o'clock.—The four-o'clock,[48] sometimes called the "marvel-of-Peru," is normally a perennial in its native region, the warmer parts of America, but under garden culture gives satisfactory results when treated as an annual (fig. 44). The seed may be sown under glass and the plants set out after danger from frost is past. The four-o'clock is often used as a low screen with good results. The colored part of the flower is white, various shades of red and yellow, and striped.

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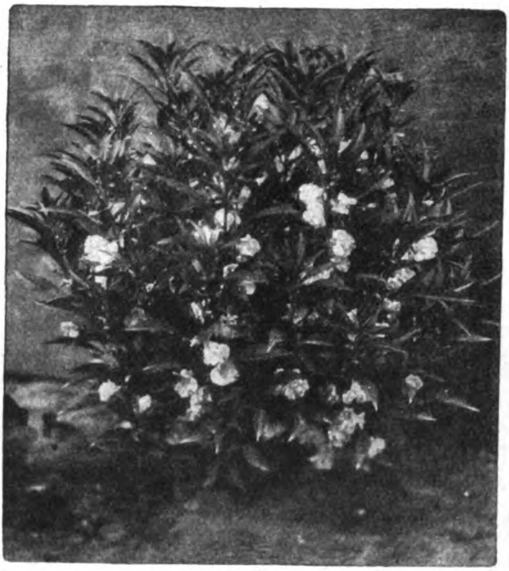
[47] *Euphorbia marginata* Pursh.

[48] *Mirabilis jalapa* L.

The plant is a quick-growing, erect, bushy herb that is easily handled, and attains a height of 18 inches. Its blooming period is during the late summer and autumn. Because of its habit of opening its flowers only late in the afternoon and on cloudy days the popular name four-o'clock has been given to it. While this plant is a tender annual in the northern part of the United States, it often reproduces itself from self-sown seed, and even as far north as New York City it **frequently manifests its perennial habit**



GARDEN BALSAM

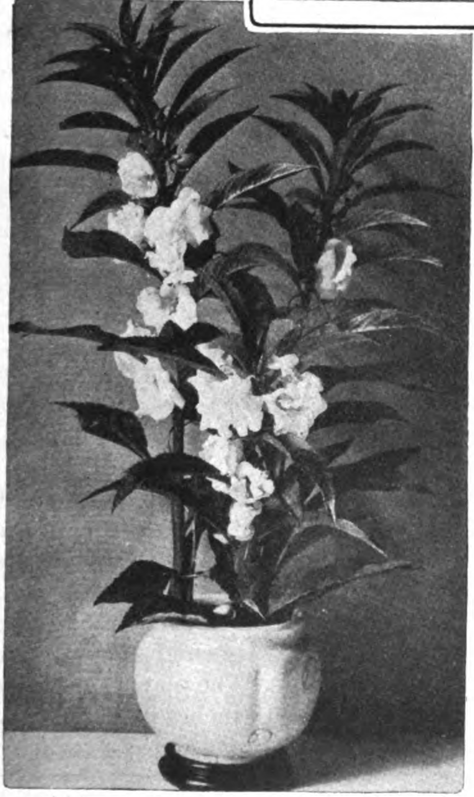


FIG. 42.

of developing tuberous roots sufficiently large to be lifted and stored like those of the canna.

Godetia.—The godetia [49] is a close relative of the evening primrose. The native California godetias are spoken of as "farewell-to-spring." It is a choice free-blooming annual with widely open flowers (fig. 45) of satiny texture and delicate rose, light purple, and white. They are suited for solid beds, border lines, for pots, and to grow in shrubbery borders in shaded places where few other flowers will flourish. The seed should be sown in the open or in a coldframe in spring. If the latter, the seedlings should be transplanted to stand about a foot apart in rather thin or sandy soil. These plants are successfully treated as biennials by sowing the seed in July and in the North transplanting the young plants to a coldframe, to be placed in the open the following May. The blooming season is from early spring until frost, and the average height of the plants is 1½ feet.

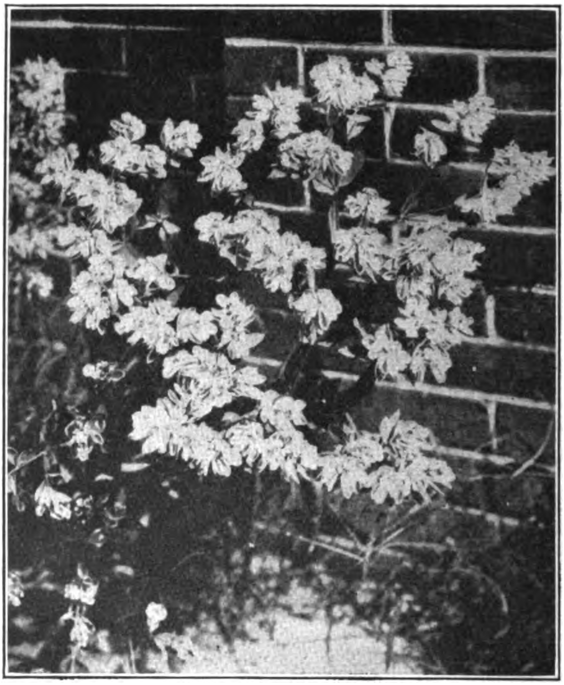


FIG. 43.—Snow-on-the-mountain.

Globe amaranth.—The globe amaranth,[50] sometimes called bachelor's-button, is an attractive and useful bedding plant growing to a height of 12 to 24 inches. The flowers are predominantly red and somewhat resemble clover heads (fig. 46). They are often cut as everlastings. The seeds should be sown in the open ground soon after freezing weather is past, or they may be started under glass if desired.

Job's-tears.—Job's-tears [51] is a grasslike annual, suggesting diminutive corn in its habit of growth (fig. 47). Its chief attraction is the beautiful seeds that are often used as beads. The plant itself is graceful, though not attaining a height of over 18 inches in the North. In the South it grows much larger, even being suggested as a forage crop.

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[49] *Godetia amoena* Lilja. [50] *Gomphrena globosa* L. [51] *Coix lachryma-jobi* L.

About the date of the last frost, seed should be sown where the plants are to grow. Two or three plants may grow together in clumps 8 to 10 inches apart.

Mignonette.—Every indoor or outdoor garden must have mignonette[52] in plentiful supply. The seed can be sown at any time, and if successive plantings are made its fragrant modest-colored flowers (fig. 48) may be gathered outdoors until November. It is of easy culture. For early blooms in the open, seed should be sown in pots or boxes under glass eight or ten weeks before danger of frost is over and the seedlings thinned or potted off to make stocky plants for bedding out as soon as severe frosts are past. To insure a succession of bloom throughout the season, sow a row or two at a time in the open about two or three weeks before time for the last frost, repeating regularly at intervals of about three weeks until August. The July sowing will make good winter-flowering plants. The average height of mignonettes is from 9 to 18 inches.

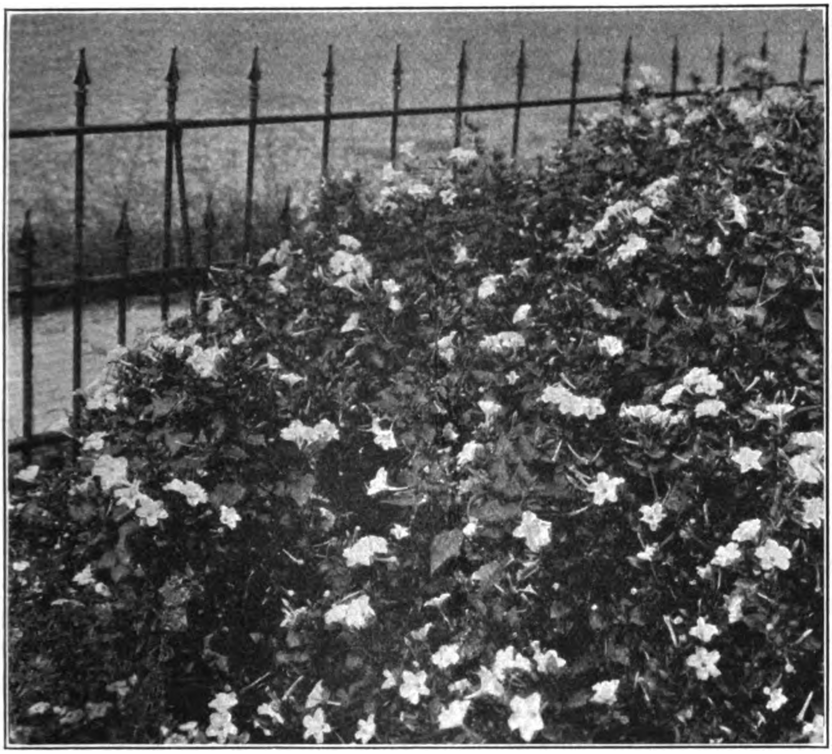

FIG. 44.—Four-o'clock.

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[52] *Reseda odorata* L.

Rose everlasting.—Rose everlasting,[53] listed in florists' catalogues as acroclinium, is attractive in a mixed border and can also be cut as an everlasting. Its flowers are white or rosy pink, and the plant grows to a height of about 15 inches. It should be sown in the open ground after the heaviest frosts are past.

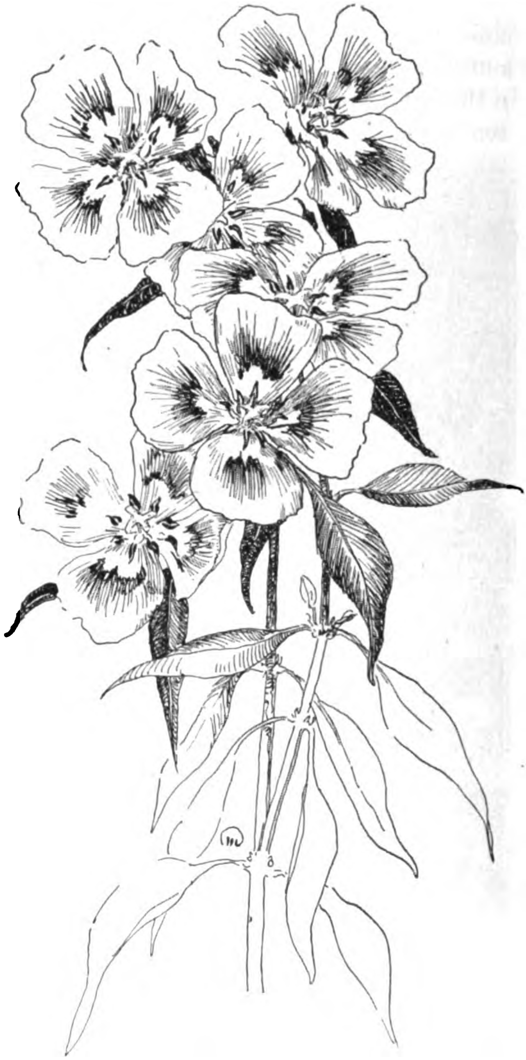

Fig. 45.—Godetia.

Stock.—The group of plants known as stocks[54] offers many desirable qualities. The plants are easily grown, vigorous, have good habits (fig. 49), fragrant flowers in various colors, a long season of bloom, and are adapted to a wide range of cultural conditions. Stocks are suitable for bedding, edgings, pot culture, house or conservatory use, and for cutting. For bouquets and floral work the double white sorts are especially useful, although there are also rose, purple, crimson, and other colors. To secure early flowers, seeds should be sown under glass before freezing weather is gone and the young seedlings transplanted when an inch high into other pots or boxes or into the fine soil of a spent hotbed. Advantage should be taken of showery weather, as soon as danger from frost is past, to transfer the plants to garden beds of deep rich soil, setting them about a foot apart each way. As with other plants, frequent transplantings during the early

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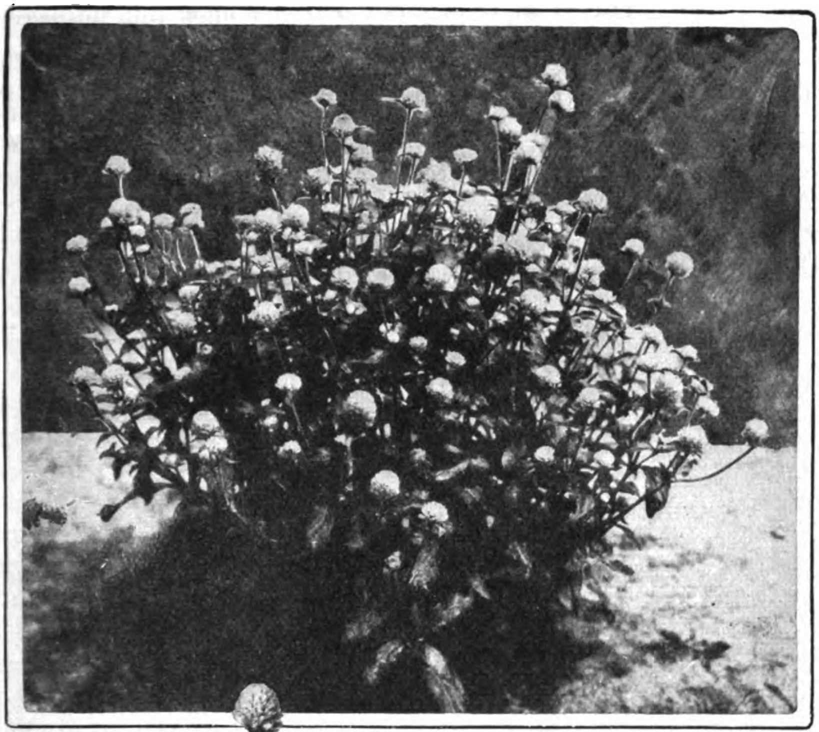
[53] *Helipterum roseum* Benth. and other species.

[54] *Matthiola incana annua* Voss.



GLOBE AMARANTH

stages of growth tend to give them a more dwarf and compact habit. For late flowers seed sowings may be made in the open ground a little before the last frosts may be expected. If plants that began to bloom late are carefully lifted and potted in the fill they will flower freely during the winter in a house or room that is tolerably cool and moist. The blossoms are very lasting. The average height of the stocks is from 12 to 18 inches.

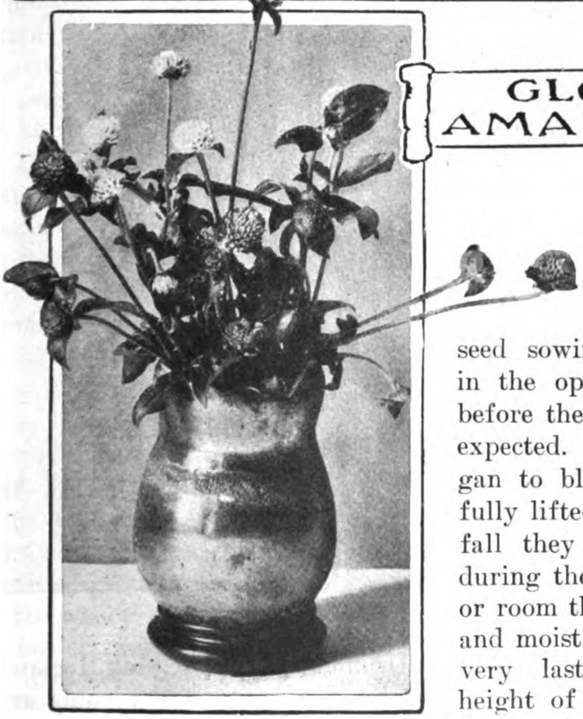


Fig. 46.

PLANTS GROWING ABOUT 12 INCHES HIGH.

Plants that are 12 inches high and of upright growth are the calendula, some dwarf varieties of calliopsis, candytuft, Cape marigold, French marigold, annual (or Drummond) phlox, pink, Iceland poppy, and nemophila, while the California poppy and petunia are

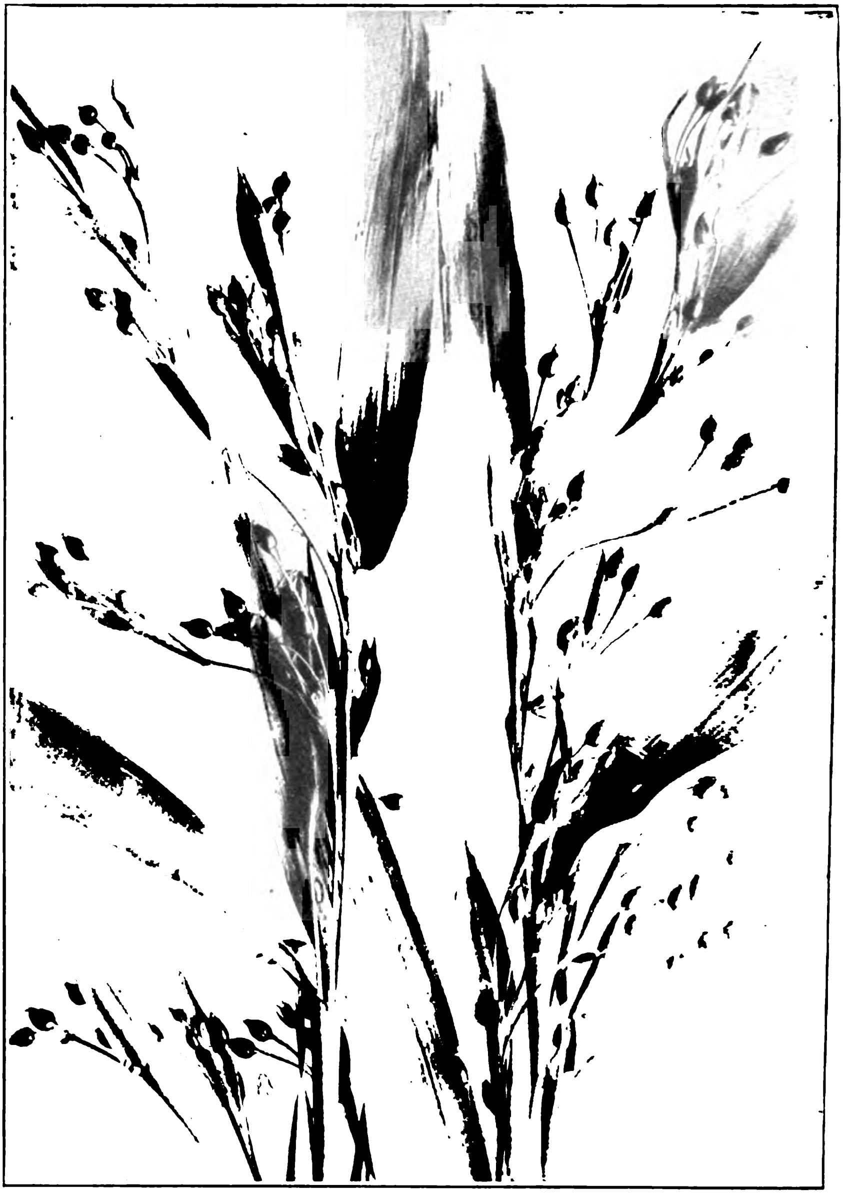


FIG. 47.—Job's-tears.

spreading and will grow much farther than 12 inches, though they will not get higher than this unless supported in some way.

Petunias can be trained on a support to a height of 3 feet or more, but the California poppy can not be handled in this way because of its tender stems that do best resting on the ground.

Miniature sunflowers about 1 foot in height may also be obtained.

Calendula, or pot marigold.—The calendula,[55] or pot marigold, is a hardy annual about 1 foot high. A moderately rich light soil is most congenial to these plants, but they are readily grown almost anywhere. They should be placed about 8 or 10 inches apart if planted in masses (fig. 50) or in borders. The seed may be sown in the open ground quite early in the spring, and the plants will be in bloom early in summer and continue to bloom until late in the autumn. The coloring of the flowers ranges through all shades of yellow, from ivory to deep orange. The plants bloom freely and earlier than the marigold and are useful in beds, borders, or backgrounds. The dried flowers are sometimes used for flavoring soups and stews. There are both single and double forms of the pot marigold. One of the most satisfactory methods of propagating this plant is from seeds sown about six weeks before danger of frost is past in spent hotbeds or in coldframes. About or a little after the date of the last frost it will

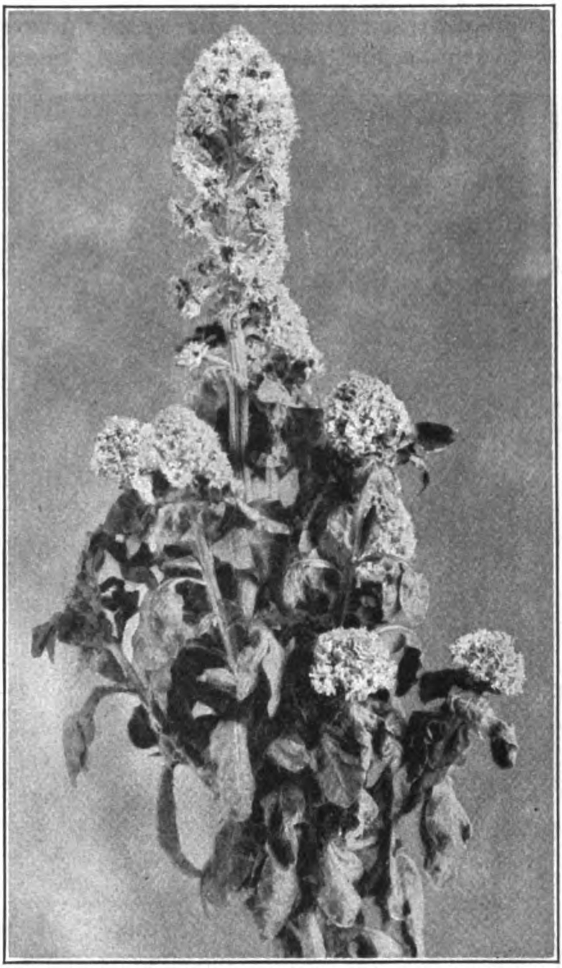


FIG. 48.—Mignonette.

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[55] *Calendula officinalis* L.

be safe to transfer the young plants to their permanent summer quarters.

Candytuft.—Candytuft[56] is among the best of the white flowers for edging beds (fig. 51); for planting in belts, beds, or for massing; for rockeries; and for cutting. Several of the varieties are fragrant; all are profuse bloomers and are easily grown. There are also crimson, carmine, and lavender varieties. Soon after freezing weather is past the seed should be sown outdoors where the plants are to bloom. They should be well thinned when they have grown about 1 inch high. A second planting should be made a month later, and a third late in July for fall flowers. September sowing will give winter-blooming plants. The soil for best results should be rich and the plants given an abundance of water. They branch freely, and if some of the buds are removed the flowers remaining will be larger.

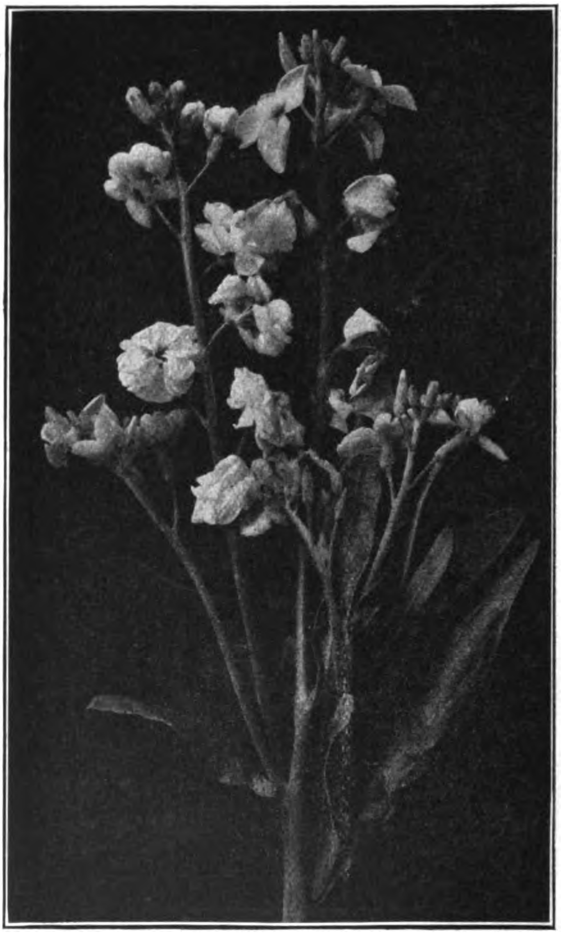

FIG. 49.—Stock.

Cape marigold.—The Cape marigold,[57] also called African golden daisy (fig. 52), is an attractive orange to deep-yellow showy flower, growing 1 foot or more high and as broad. It is especially adapted to dry sunny locations. Seed should be sown outdoors after freezing weather is well over, or it can be sown earlier under glass and be transplanted to flats or pots and then set in the open ground after danger from frost is past.

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[56] *Iberis umbellata* L., *I. amara* L.

[57] *Dimorphotheca aurantiaca* DC.

French marigold.—The French marigold[58] (fig. 53) is more compact and regular in growth than the African marigold and consequently is more valuable as a bedding or low border plant. The habit of growth is erect and compact, with good foliage. The flowers are well formed, of bright yellow and orange colors, and occur from June until frost. While these plants can be grown easily and successfully brought into bloom from seeds sown in the open after danger of frost is past, they do not give as early bloom or the profusion of flowers which will be borne by plants that are started in a house and shifted for a time into pots, which confine the roots and check the plant, so that when set in the open ground the increased food supply will have a tendency to induce the development of flowers rather than wood, a tendency which will be likely to be maintained throughout the season. When transferred to the open the plants should be set at least 1 foot apart each way. The same distance should also be given the plants grown from seed sown in the open. There are both double and single forms of the French marigold. The named varieties are especially good, but very satisfactory results are obtained from mixed seeds.

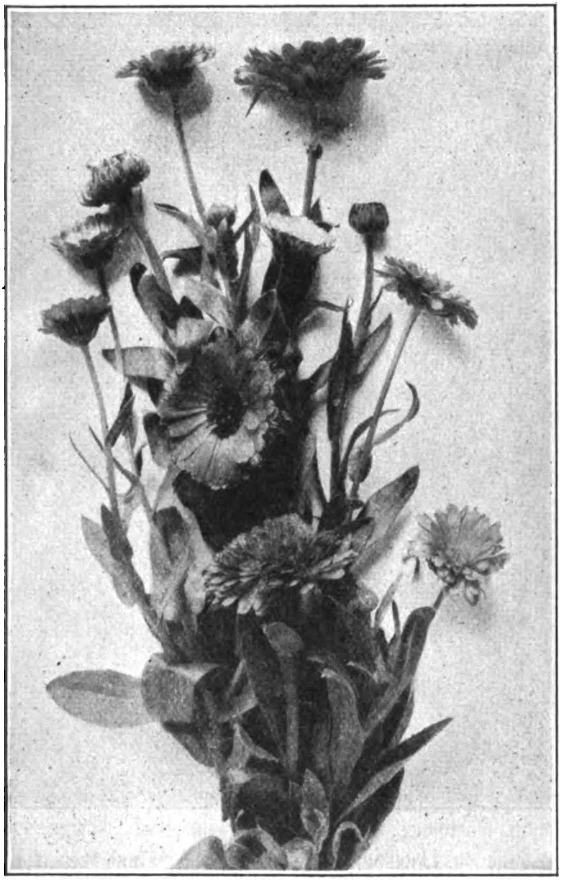

Fig. 50.—Calendula.

Phlox.—The annual, or Drummond, phlox[59] is particularly useful and attractive when sown in masses or ribbon beds of contrasting colors. Few annual plants are more easily grown from seed, give a quicker return of bloom, or offer such a variety to choose from as do the phloxes. They are rich in reds, with a few varieties approaching buff and lilac (fig. 54). If given good soil, plenty of water, and full sunshine, they furnish throughout the season a supply of delicate flowers for cutting. The phloxes are also useful as window-garden plants and may be used as an undergrowth for tall bare-stemmed plants. The first sowing of seed should be made as soon as frost is out of the ground in the spring; another a month later, either where the plants are to bloom or in a seed bed, as the phlox transplants readily. In transplanting set the taller kinds about a foot apart. If planted too thickly they suffer from mildew. The removal of flowers and seed pods makes the plants more bushy and compact and lengthens their blooming period. The average height of the plants is about a foot.

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[58] *Tagetes patula* L.

[59] *Phlox drummondii* Hook.

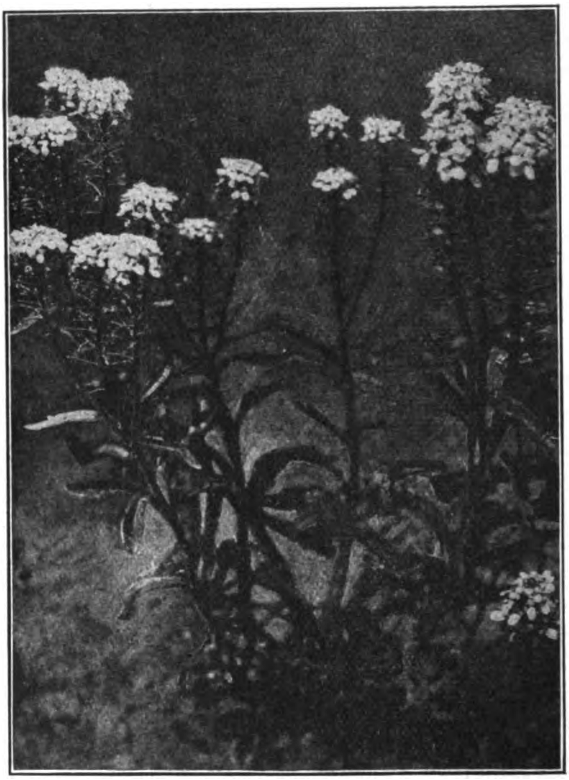
FIG. 51.—Candytuft.

Pinks.—The large and varied genus of Dianthus contains some of our most beautiful and most profitable flowers (fig. 55). Most are hardy perennials that bloom freely the first season, the plants remaining green all winter and blossoming the next year if lightly protected by a mulch of straw, cut fodder, or leaves. Old plants flower earliest, but as young ones give the largest, finest flowers, sowings are made every year. Seed can be sown under glass or in an open sheltered bed as soon as the frost is out of the ground. The seedlings are easily transplanted and should stand 8 to 12 inches apart; dwarf ones, about 6 inches. If especially large brilliant flowers are desired, a bed of well-mixed turfy loam, leaf mold, and well-decayed manure should be prepared for them. Good drainage should be provided, as the plants are impatient of too much moisture and are more liable to winterkill in moist than in well-drained situations; in fact, the plant is hardy to severe cold, but succumbs when exposed to low temperatures in wet places.

The flowers of all the plants of this group are most satisfactory for bouquets and table decorations because of the length of time they will keep in a fresh and attractive condition after being cut and placed in water. Their colors are chiefly white and shades of red.

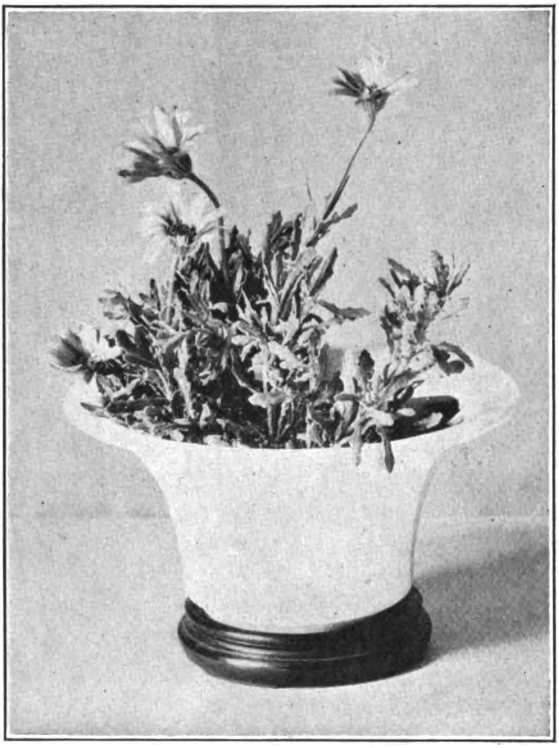

FIG. 52.—Cape marigold.

The carnation pink,[60] which is the forcing carnation of the American florist, can be grown from seeds, but it usually will not bloom until five months or more from planting. The seeds should be sown very early in the season in hotbeds, the young plants being given frequent shifts to pots of increased size as they grow until all danger of frost is past and the growing season is well on, when they may be transferred to the border where they are to bloom. If they are given a rich soil and an abundance of moisture the blooms will more than repay the extra trouble taken, but they are not to be counted on for very satisfactory results until the second season. Seedling plants are more variable in character than plants propagated from cuttings, and for that reason seedlings are not used by florists except in seeking for new varieties.

On the continent of Europe this type of dianthus is more commonly used as a garden annual than in America. The form known as the "Marguerite carnation,"[61] which has recently come into popular

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[60] *Dianthus caryophyllus* L.

[61] A hybrid derived from *Dianthus chinensis* and some other species.

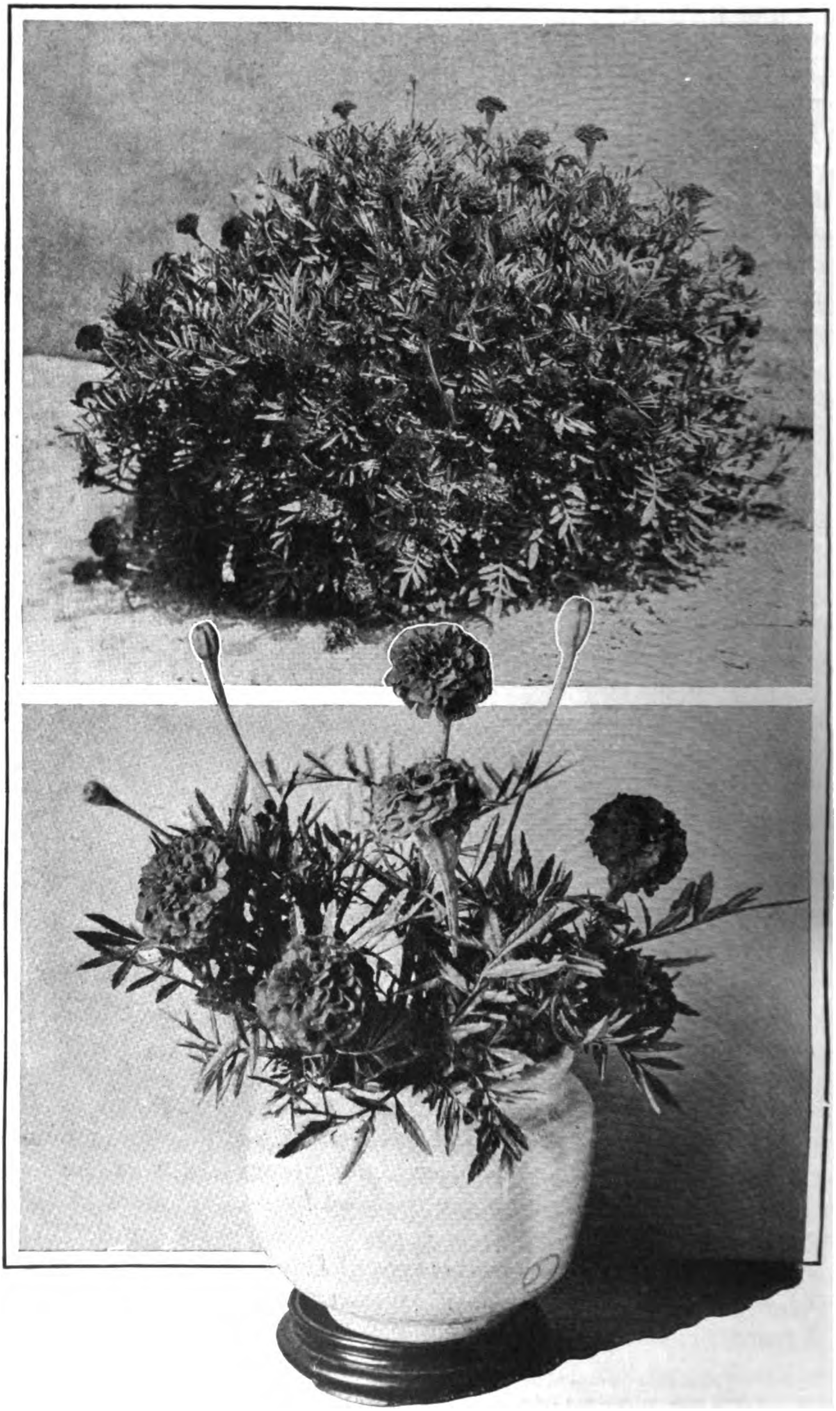

Fig. 53.—French marigold.

favor, is well adapted to cultivation as an annual. Most of its flowers come double, and it has a pleasing habit of growth.

The hybrid sweet-william[62] is one of the most satisfactory members of this group for annual planting. While seed can be sown in the open about the time frosts are over, the best results in the way of early bloom come from plants produced from seeds sown in a hotbed not later than six weeks before the last frosts, the young plants being pricked out into flats or, preferably, into thumb pots, and later shifted to 3-inch pots before planting in the flowering border. The outside planting of hotbed-grown plants should be delayed until the season has advanced sufficiently to prevent the plants from suffering from a check by cold after being placed in the open. The pot-grown plants should be set at least 10 inches apart, and seedlings from seeds sown in the open had best be thinned to stand at least 8 inches apart.

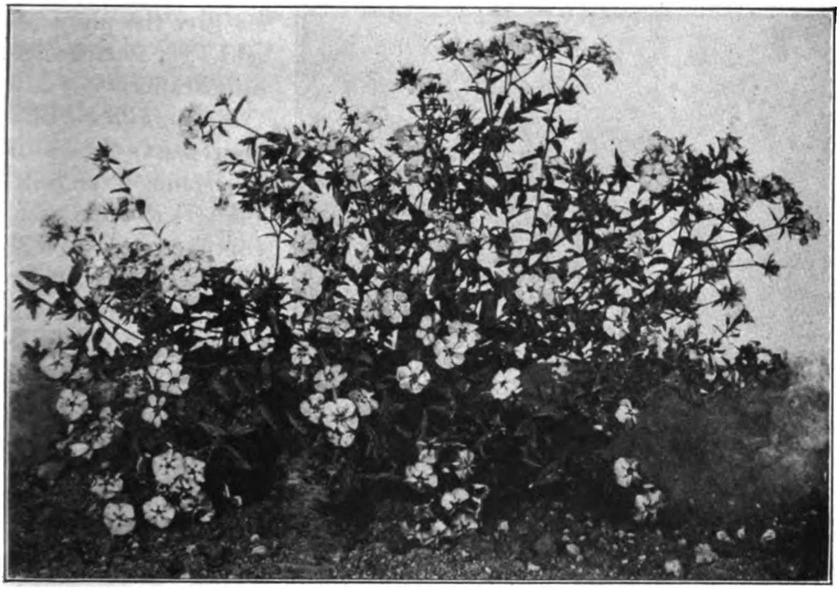

FIG. 54.—Drummond phlox.

The sweet-william[63] of old-fashioned gardens is a perennial, or at least a biennial, and needs to be sown in the summer for satisfactory results the following year.

One of the handsomest, easiest grown, and most satisfactory annual pinks is the Japanese pink.[64] Seed sown early under glass or outdoors as soon as the ground is settled will give blooms by midsummer or before, and the plants will continue blooming until frost. Seed sown later will give some very late blooms and an abundance of fine flowers the next spring. There are both single and double varieties.

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[62] *Dianthus latifolius* Hort.

[63] *Dianthus barbatus* L.

[64] *Dianthus chinensis heddewigii* Regel.

The Chinese pink,[65] which is somewhat similar to the Japanese pink, is also a satisfactory plant handled in the same way. The varieties usually offered are double.

The fringed pinks,[66] both single and double, are admired by many and are easily grown, satisfactory plants that do best in poor soil with plenty of sun.

The Scotch pink,[67] or grass pink, is a hardy dianthus which, when treated as an annual, like the hybrid sweet-william, gives very satisfactory results. The delicately fringed variously colored pink and white fragrant flowers give the plant an odd yet attractive appearance.

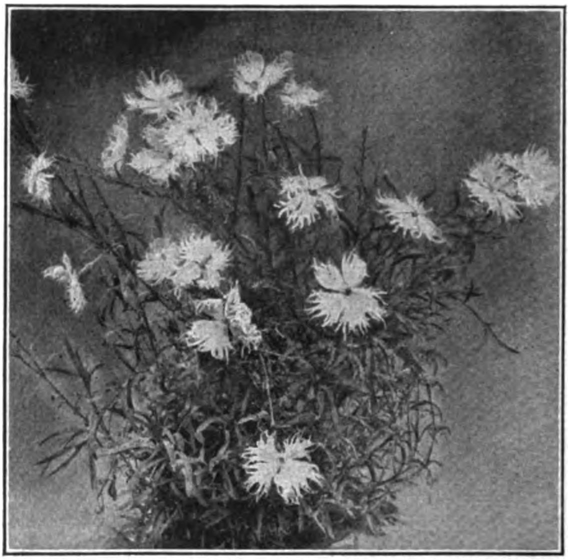

FIG. 55.—Japanese pink.

Nemophila.—The representatives of the genus Nemophila[68] are dwarf, compact-growing, hardy annual herbs, about 12 inches in height, which produce an abundance of showy, bell-shaped flowers from early spring to late autumn, for which reason they are esteemed for borders and for bedding purposes. All the species may be propagated from seed. For summer and late fall blooms the seed may be sown in the open as soon as freezing weather is past, the plants being left without transplanting. The nemophilas love a cool, moist loam with partial shade and produce an abundance of showy blue, violet, and white margined and dotted flowers, which are very valuable for bedding and for cut flowers. These plants are especially adapted to the cooler parts of the country or for winter culture in the South. If the seeds are sown in the open about the middle of August and the seedlings transplanted in late autumn, very early flowers may be obtained.

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[65] *Dianthus chinensis* L.

[66] *Dianthus chinensis laciniatus* Regel.

[67] *Dianthus plumarius* L.

[68] *Nemophila menziesii* Hook. and Arn.

Poppies.—The Iceland poppy[69] is a dainty and attractive perennial that comes into bloom almost as soon as the true annual poppies (fig. 56). It grows about a foot high and bears its yellow, white, and deep-orange flowers on slender, graceful stems. If cut before opening, the blossoms keep quite satisfactorily. If the dead blossoms are kept picked off, the plants will continue to blossom the whole summer. Seeds are best sown where the plants are to grow, as early in the spring as the ground can be worked. The plants should be thinned to about a foot apart.

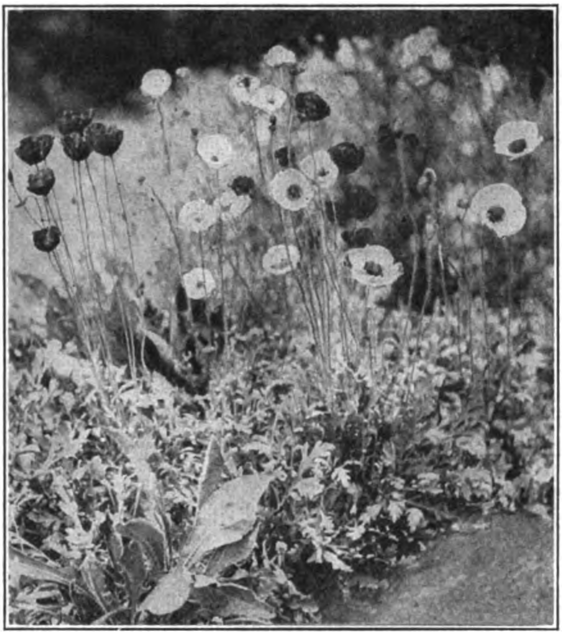

FIG. 56.—Iceland poppy.

The California poppy[70] is the State flower of California and an annual of striking character (fig. 57) as regards both the form and the color of its flowers, which are bright and rich in their tints of yellow and orange. The plants average about a foot in height, have attractive silvery foliage, and produce their large poppylike flowers quite lavishly from early spring until frost. They are most effective when grown in beds of considerable size, over which the seed may be thinly sown broadcast and then lightly raked in. These sowings may be made early in the spring or late in the fall for early germination and bloom the next spring. The California poppy is also very useful as a pot plant and for cut flowers. It is easily grown.

Petunia.—Because of the ease and facility with which all of the single-flowered varieties of the petunia[71] can be grown from seed, this plant commands attention as a worthy candidate for the summer flower garden (fig. 58). The young plants grow rapidly and come into bloom early, and in addition to this they furnish a continuous wealth of blossoms until destroyed by frost. The large-flowered strains are very beautiful and of great variety. While the single sorts are common and inexpensive, the double giant-flowered varieties are rendered expensive because they must be reproduced from seed which sets only after careful hand pollination of the flowers, which is in itself an expensive operation, or from cuttings, of which an individual plant can supply but a limited number. The colors range from white through rose to almost purple.

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[69] *Papaver nudicaule* L.

[70] *Eschscholtzia californica* Cham.

[71] *Petunia axillaris* B. S. P. (*P. violacea*).

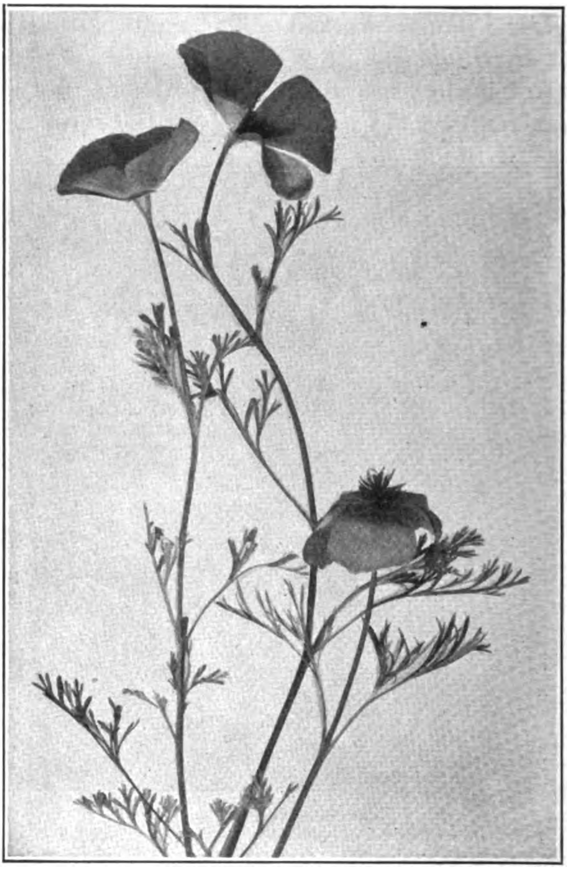
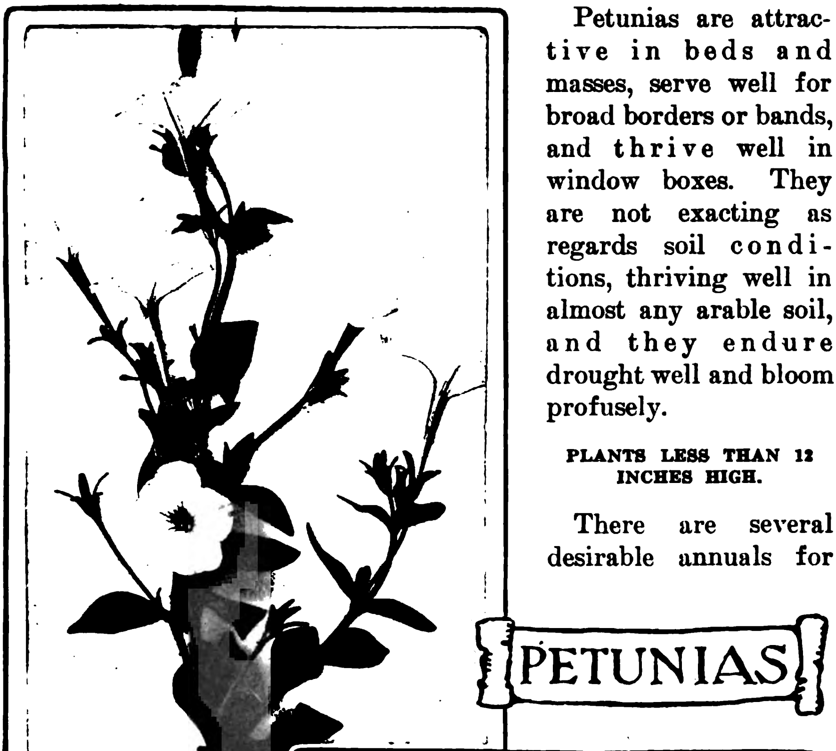


FIG. 57.—California poppy.

For the best results the seeds of all sorts should be sown in a gentle hotbed, coldframe, or in fine soil in a box placed in a sunny window before or by the time freezing weather is over. When the soil has warmed sufficiently and the danger of frost has passed, the seedling plants should be transplanted to a rich garden loam and placed about a foot apart each way. The seed of the double varieties is less vigorous than that of the single sort; therefore, to insure good germination, it requires more attention to prevent extremes of temperature and of moisture. If the seeds are sown in boxes in a living room, a pane of glass may be kept over the top to maintain a close atmosphere and thus prevent the loss of moisture until the young plants are well out of the ground. In planting, the seeds should be scattered over the surface of the soil and brought in contact with it by firming. They should not, like most other seeds, be covered. In transplanting, the weaker, slower growing seedlings should not be ignored, as they are likely to be the plants that will produce the finest blossoms.



Petunias are attractive in beds and masses, serve well for broad borders or bands, and thrive well in window boxes. They are not exacting as regards soil conditions, thriving well in almost any arable soil, and they endure drought well and bloom profusely.

PLANTS LESS THAN 12 INCHES HIGH.

There are several desirable annuals for ornamental planting that do not grow to a height of a foot. Among these are the ageratum, lobelia, dwarf nasturtium, pansy, portulaca, sweet alyssum, tagetes, forget-me-not, and verbena, while the cockscomb has dwarf varieties less than a foot in height.

Ageratum.—"For strengthening the garden's color forces in blue, no annual is so good as the

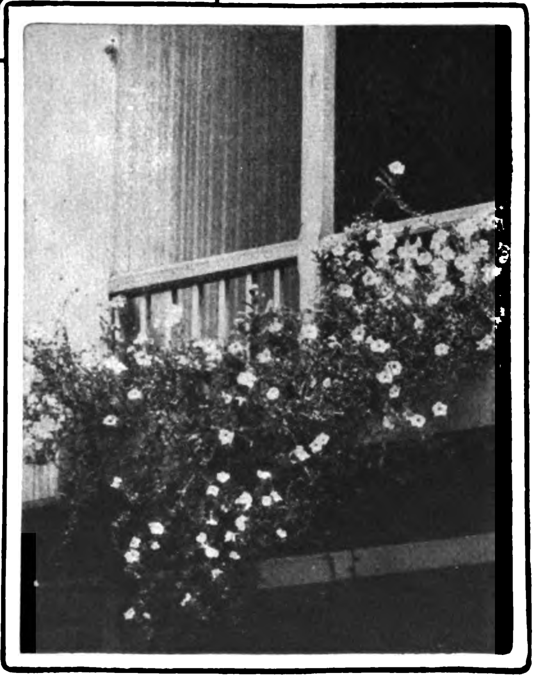


FIG. 58.

ageratum."[72] Though ordinarily used in bedding and borders in contrast with such plants as geraniums, perillas, amaranthus, etc., the rose, white, and blue ageratums are exceedingly attractive when mingled with alyssum, candytuft, and similar plants. They grow well upon almost all soils and through a wide range of climate; for that reason many combinations with them are possible. The plants are easily grown, neat, bushy, and erect, with a continual profuse clustering of pretty brushlike flowers (fig. 59) throughout the season. The dwarf blue sorts make fine borders and are much used where contrasting color effects are desired. For early results the seed should be sown in coldframes or boxes in the house early in the season before freezing weather is past, but for summer and fall blooms the seeds may be sown in well-prepared beds in the open after the ground stops freezing. Seeds sown in August will produce good plants for winter flowering.

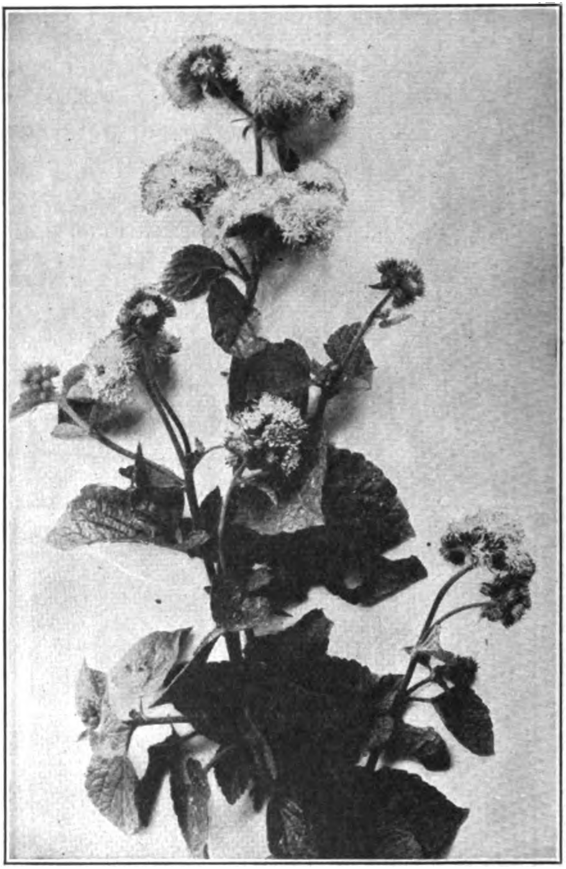


FIG. 59.—Ageratum.

Lobelia.—The lobelias[73] are charming little plants that bloom very quickly from seed and continue gay with flowers all through the season. For beds, edgings, baskets, and pots there is nothing prettier; their clear white and shades of blue and generous bloom make them welcome anywhere (fig. 60). The seeds may be sown outdoors in early spring where the plants are to grow. As the plants appear they should be thinned moderately or transplanted several inches apart in rich open soil.

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[72] *Ageratum conyzoides* L., *A. houstonianum* Mill.

[73] *Lobelia erinus* L.

Liquid manure applied while they are in bloom greatly improves the flowers. Many sorts are also good winter conservatory plants of trailing habit. There are perennial or tall varieties that are handsome, showy plants with red or with blue flowers, quite effective for backgrounds and grouping.

Dwarf nasturtium.—A wide range of color has been developed in the dwarf, or Tom Thumb, nasturtium,[74] which for three or four months of the season makes a better display than almost any other plant (fig. 61). No annual will produce such a profusion of flowers for so long a time with the same outlay of time and labor. The maximum of bloom is produced on thin soil, and the plant never flags through the hottest weather; in fact, too much rain or moisture greatly reduces the supply of flowers. In soil too rich the leaves predominate and the plants are apt to rot off in wet weather, especially if standing too close. The seeds should be planted an inch deep just after the last frost, and the seedlings should be thinned to 10 or 12 inches apart. The rows should be not less than a foot apart.

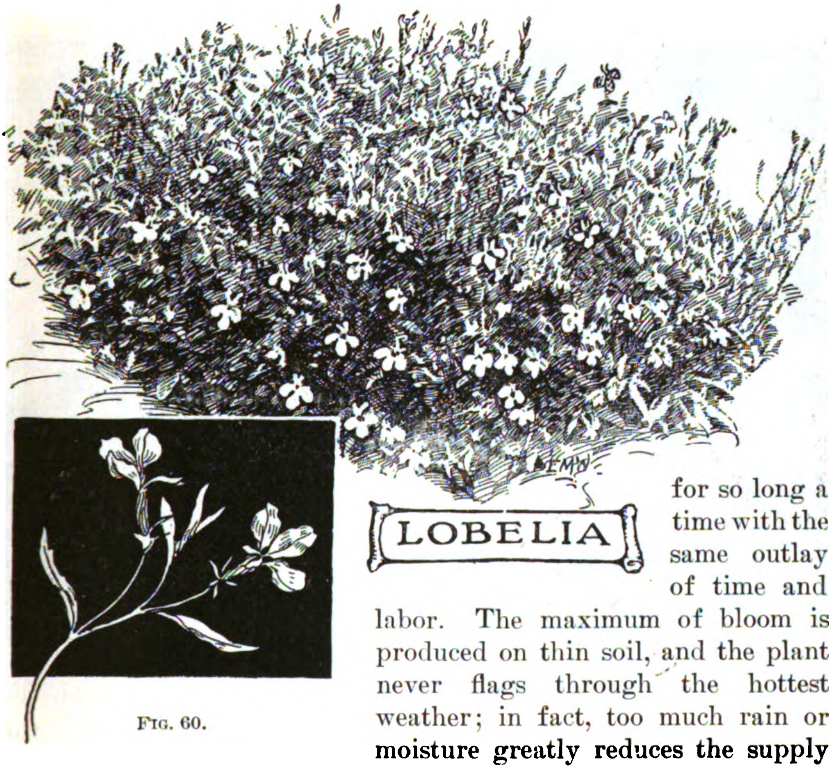

FIG. 60.

These plants have a neat, compact habit of growth and attractive foliage and are not infested by insects. Blossoms appear in two months from the date of seed sowing and continue throughout the whole season. A bed of dwarf nasturtiums in full bloom is a sea of yellow and orange, mixed with browns, maroons, and lemon. It is said that a good bed, 6 by 20 feet in size, will yield about 1,000 flowers each day. The average height is 9 inches.

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[74] *Tropaeolum majus nanum* Hort.

Pansy.—The pansy,[75] sometimes called heartsease (fig. 62), is a favorite with almost everyone. The flowers are usually yellow or purple, sometimes almost white or almost black, but usually more or less splotched. The pansy is a plant that demands more than ordinary attention, but none repays such attention more liberally. For very early outdoor bedding the seed is sown in the autumn (September) in a coldframe or in rich moist garden beds. from which the plants can be transferred before severe winter weather begins. South of Cincinnati and St. Louis the transplanting can be to the beds where they are to bloom. North of these cities they should be transferred to a coldframe, setting them 2 or 3 inches apart each way. In the spring three-fourths of them can be lifted out for bedding and the rest left to bloom in the frame. For winter bloom in a frame set the plants about twice as far apart and thin out half of them in the spring. Cover the blooming plants with sash, adding a covering of matting or straw in very cold weather. In mild weather remove the mats and tilt the sashes to admit light and fresh air and to prevent the plants from becoming drawn. In outdoor beds raised a few inches above the ground, with a mulch of dry leaves and some brush to hold them in place, pansies will often winter

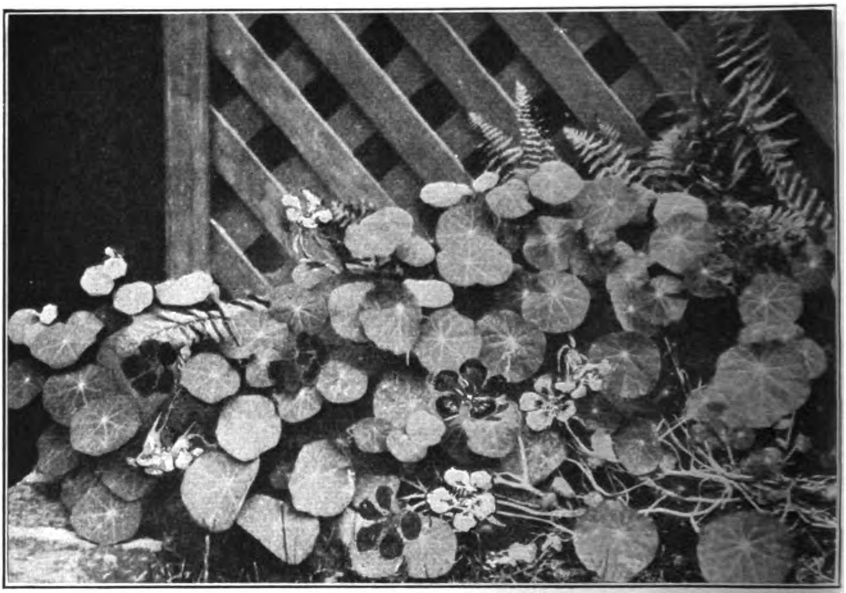

FIG. 61.—Nasturtium.

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[75] *Viola tricolor* L.

nicely in the North and bloom until midsummer, when a relay of young vigorous plants should be ready to replace them.

Spring sowings should be made early, so as to secure good flowers during the early rains. Seeds sown in a cool, moist place in June and July and well tended will give good flowering plants for fall. If they come into bloom in the heat of the summer, the flowers may be small at first; but as the weather becomes cooler they will increase in size and beauty. Through the summer heat the flowers are finer in a somewhat shaded place, but in almost any situation good pansy seed will produce fine flowers in spring and fall. Early fall sowings give the finest spring flowers.

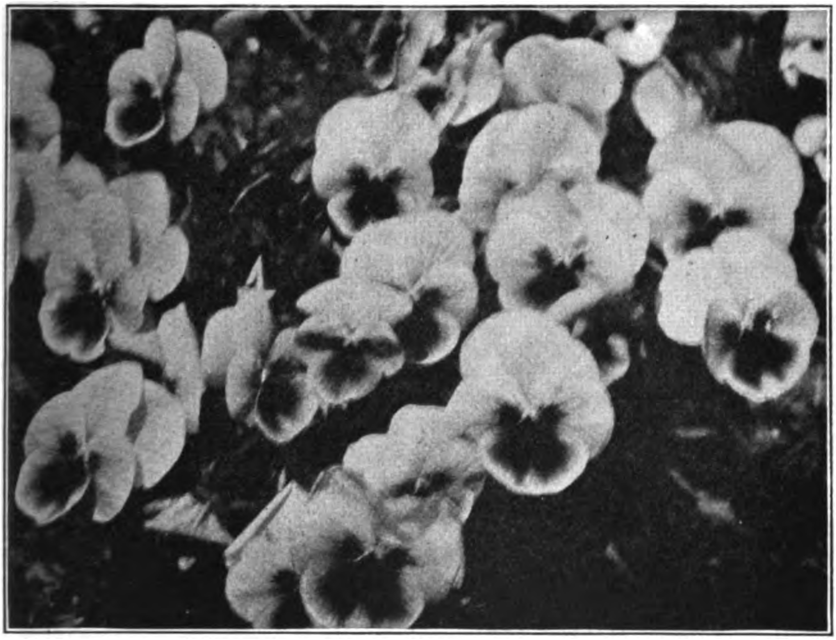

FIG. 62.—Pansies.

In the South much better results may be expected with these plants in the winter than in the summer.

Portulaca.—The bright-flowered thick-leaved portulaca,[76] sometimes called sun plant, is unrivaled for brilliancy among plants of low growth. It possesses the ability to flourish under extremely adverse conditions; even the hot sun and a light sandy soil with sparse water supply will not destroy it. It is satisfactory for beds, edgings (fig. 63), and rockwork, and for filling up irregular spaces or unexpected gaps in flower beds; as an undergrowth for taller plants it is also valuable. It carpets the ground with a mat of succulent foliage that in the forenoon is hidden by the gayest flowers, ranging through the reds and yellows. The plant is particularly useful in the Northwest. The seed does not germinate until hot weather and should be sown late. Beyond the sowing this plant requires little care. The hardy character of the plant is shown by the fact that it can be transplanted while in full flower through the driest, hottest seasons. The average height is 6 inches.

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[76] *Portulaca grandiflora* Hook.

In the southern half of the country portulaca will perpetuate itself by self-sown seeds. In some soils this is sufficient to cause the plant to assume a weedy character. It never becomes troublesome like its near relative, the weedy garden purslane, or "pusley" (*Portulaca obracea*).

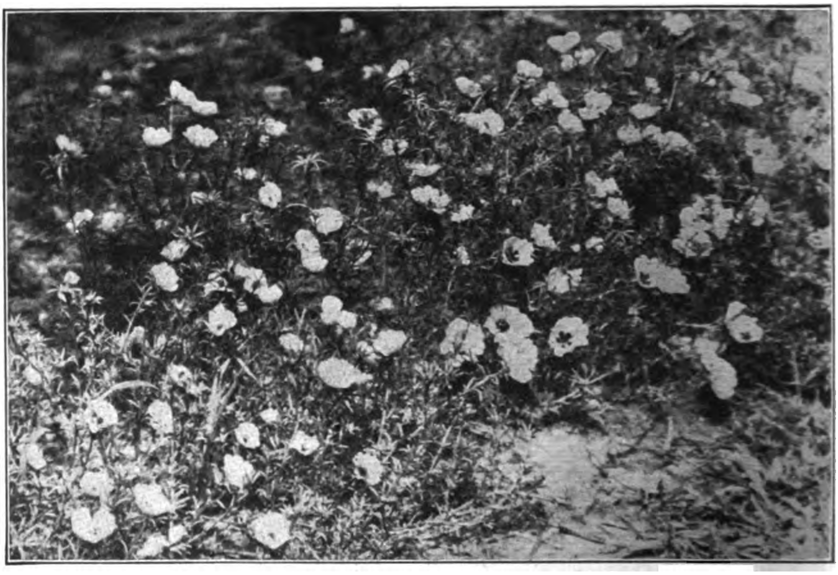

FIG. 63.—Portulaca.

Sweet alyssum.—Sweet alyssum[77] is a most easily grown, dainty little white flower, recommended to be used liberally for borders, edgings, baskets, pots, rockwork, and for cutting (fig. 64). For borders the seed should be sown thickly, so as to form masses. For winter bloom sow late in August and thin the seedlings to stand about 4 inches apart, but for spring bloom for borders the seeds should be sown in the open early in the spring, or even late in the preceding autumn in some localities. Where the plant will not endure the winter, however, early spring planting under cover, either in a coldframe, a spent hotbed, or in boxes in a dwelling, is most to be relied upon. Sweet alyssum can also be increased from cuttings made from strong new side shoots, as well as by division of the roots. By cutting back after the first flowers fade others will be produced.

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[77] *Lobularia maritima* Desv. (*Alyssum maritimum*).

The Carpet of Snow variety is only about 4 inches high and is probably one of the most satisfactory, as its habit of growth is so compact that blooms that die during the season do not give it the ragged appearance sometimes seen in the larger varieties. It blooms continually from spring till fall. While sweet alyssum is white, there are perennial varieties that are yellow.

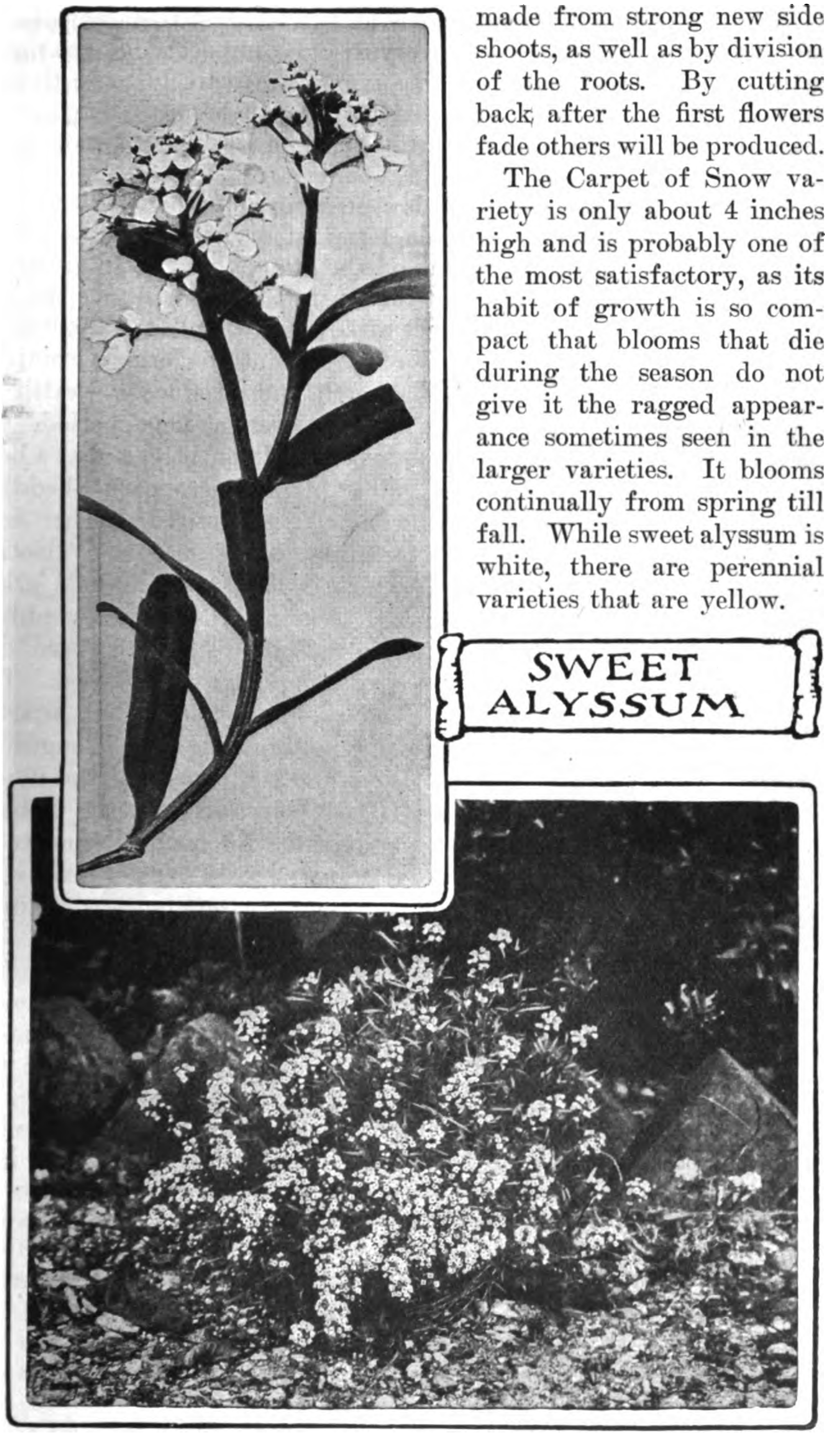

Fig. 64.

Dwarf marigold.—Dwarf marigold,[78] or as it is frequently listed in catalogues "Tagetes," is the very dwarf, compact single marigold with almost fernlike leaves. The plants are scarcely more than 8 inches tall and bear freely their bright yellow blossoms. They can be started in the open ground soon after freezing weather is past and are readily grown.

Verbena.—The verbena[79] is a low-growing annual with a creeping habit. The flowers are borne on terminal or lateral shoots which lift themselves from 5 to 7 inches off the ground, and when grown in mass the plants will form a mat that in full bloom will give the soil the appearance of having a carpet of flowers. Because of the ability of the plant to form a compact growth and produce a wealth of flowers over a long period, the verbena is frequently used as a bedding plant where carpet-bedding effects are desired. The contrasting colors in the varieties, which come true from seed, allow the securing of pleasing combinations which are effective where low-growing plants can be used. The colors include white, pink, scarlet, blue, and purple. The length of stem and the texture of the flower (fig. 65) are such that the verbena is of value for bouquets and table decorations. It can be used with good effect in beds, borders, mounds, and window boxes.

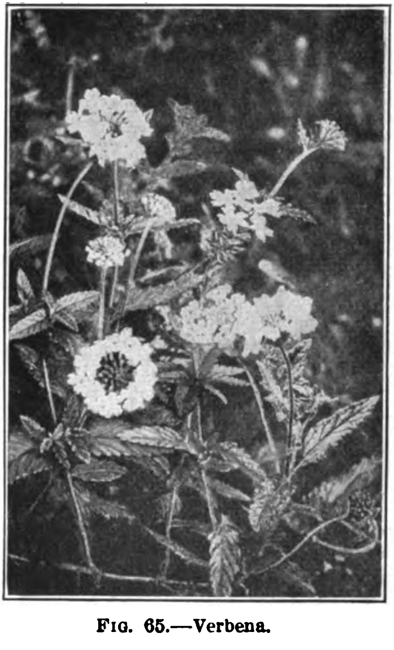

FIG. 65.—Verbena.

While the verbena grows readily from cuttings and from layers, seedling plants are more vigorous and as a rule produce better flowers. For the earliest bloom, sow the seeds at least a month before the ground stops freezing at night, starting them in a moderatly warm living room or greenhouse. For general outdoor planting the seeds may be sown about five or six weeks before the last frost either in a living room, hotbed, or greenhouse. Soak the seeds a few hours in tepid water and sow in seed boxes filled with light rich soil; cover one-fourth of an inch deep, press down firmly, and water sparingly. When the seedlings are about an inch high transplant them into other boxes, placing the young plants 2 or 3 inches apart each way. If thumb pots are available, use these in place of boxes. When all danger of frost is past choose a bright, sunny situation in which to plant them. Make the soil rich and compact rather than light, but in all cases provide good drainage. Set the young plants 10 to 15 inches apart each way and give good cultivation until they cover the ground. With such treatment the verbena should give continuous bloom from early summer until killed by frost.

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[78] *Tagetes signata pumila* Hort.

[79] *Verbena chamaedryfolia* Juss., *V. phlogiflora* Cham., *V. teucrioides* Gill. and Hook., *V. incisa* Hook.

Forget-me-not.—The dainty little blue flowers commonly known as forget-me-nots[80] (*Myosotis*) are hardy perennials that love cool, moist soils and, like pansies, bloom most freely in fall and early spring. There is also an annual species, with several varieties. They make a satisfactory close border (fig. 66), the beauty of which is heightened by abundant bloom. The forget-me-not is also satisfactory as a winter-blooming plant for growing in cool rooms or coldframes. Another feature characteristic of this plant is that, after once having been introduced into a garden, it perpetuates itself from year to year by self-seeding, like the poppy, portulaca, and several other desirable annuals. Sow the seeds in spring in a warm, sunny border, or in the South in late summer for winter bloom. Most varieties bloom freely the first season and profusely the second year if in a sufficiently cool, moist place. The average height of the plants is 6 inches. They do not succeed so well in dry, sunny situations.

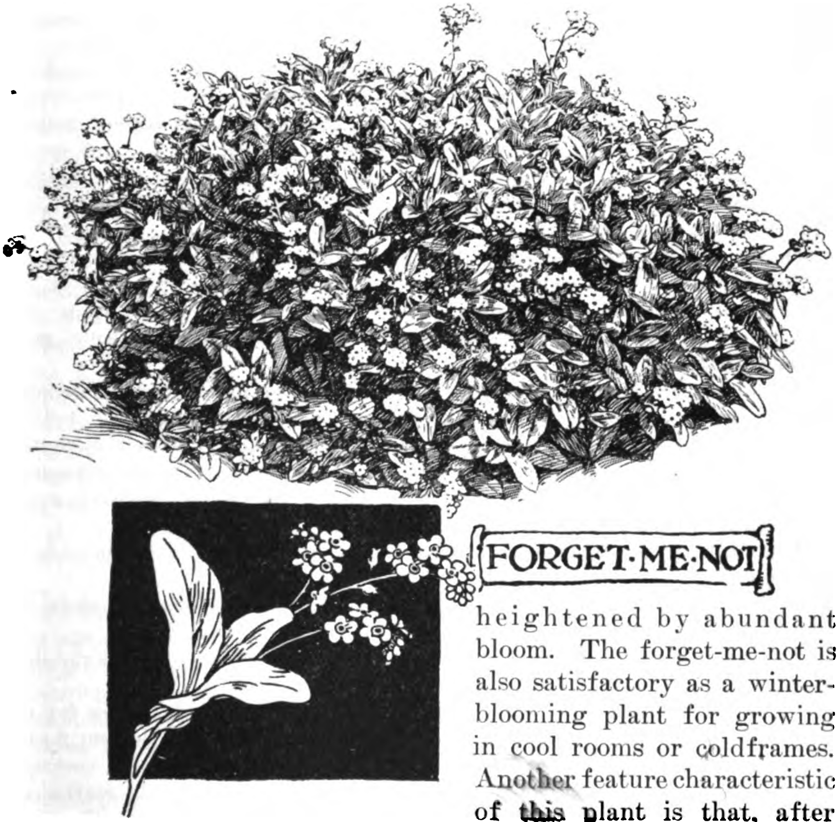

FIG. 66.

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[80] *Myosotis scorpioides* L. (*M. palustris*).

PLANTS FOR SPECIAL SOILS OR CONDITIONS.

Some plants which are desirable for special conditions are specified in the following lists:

For bright sunshine with plenty of fertility and moisture: Over 4 feet high, castor-bean, cosmos, sunflower, sorghum, feterita, milo, and Indian corn; over 3 feet, Joseph's-coat, love-lies-bleeding, plumed cockscomb, orange sunflower, prince's-feather, spiderflower, and summer cypress; 30 inches, cornflower, larkspur, mourning bride, scarlet sage, strawflower, and zinnia; 24 inches, balsam, calliopsis, China aster, summer chrysanthemum, cockscomb, coneflower, four-o'clock, gaillardia, African marigold, platycodon, poppy, salpiglossis, snapdragon, and snow-on-the-mountain; 18 inches, Job's-tears, mignonette, and stock; 12 inches, calendula, California poppy, calliopsis, candytuft, French marigold, petunia, Drummond phlox, pink, and Iceland poppy; under 12 inches, ageratum, cockscomb, lobelia, portulaca, sweet alyssum, and verbena.

Of easiest culture under ordinary garden conditions: Over 4 feet, sunflower; about 3 feet, Joseph's-coat, love-lies-bleeding, heliopsis, and prince's-feather; about 30 inches, cornflower, strawflower, and zinnia; about 24 inches, calliopsis, summer chrysanthemum, coneflower, gaillardia, marigold, poppy, and snow-on-the-mountain; about 18 inches, mignonette; about 12 inches, Cape marigold, calendula, California poppy, balsam, candytuft, petunia, Drummond phlox, pink, dwarf nasturtium, portulaca, and sweet alyssum.

On light fertile soil: Gaillardia, marigold, Drummond phlox, and portulaca.

On light soil, not too rich: Cockscomb and feather cockscomb.

On poor soil: Love-lies-bleeding, prince's-feather, Joseph's-coat, Cape marigold, godetia, dwarf nasturtium, portulaca, Scotch pink, sweet alyssum, garden balsam, and calliopsis.

On lands near the seacoast: Plants from the three foregoing lists, depending on the fertility of the soil, together with the castor-bean, sunflower, heliopsis, spiderflower, cornflower, strawflower, zinnia, calliopsis, snow-on-the-mountain, four-o'clock, stock, calendula, California poppy, petunia, and sweet alyssum.

In partial shade: Basketflower, sweet-sultan, clarkia, platycodon, godetia, Drummond phlox, pansy, sweet alyssum, lupine, and forget-me-not.

Especially responding to rich soil: Castor-bean, scarlet sage, balsam, and China aster.

To cut for everlastings: Rose everlasting, feathered cockscomb, globe amaranth, and strawflower.

Not adapted to the South except for late fall and early spring: Salpiglossis, pansy, and forget-me-not.

Plants that can be started to advantage in hotbeds and coldframes for early flowering, whether they are to be used for bedding purposes or for cut flowers: Ageratum, China aster, calliopsis, castor-bean, calendula, cosmos, cockscomb, chrysanthemum, godetia, lobelia, marigold, petunia, Scotch pink, scarlet sage, spiderflower, and verbena.

Some plants that may be sown in beds in the open ground and later transplanted to their permanent locations are the ageratum, calendula, calliopsis, China aster, clarkia, cockscomb, dahlia, gaillardia, godetia, lobelia, mignonette, pansy, pink, snapdragon, spiderflower, stock, and zinnia.

Among those that should be sown early in that way are the alyssum, California poppy, candytuft, cornflower, forget-me-not, mignonette, nemophila, Drummond phlox, sunflower, poppy, and sweet alyssum.

Most of these may be sown earlier in a hotbed or coldframe and thus be made to bloom earlier.

Some should be sown in the open ground where the plants are to grow. Among those that should be sown late in this manner after the ground is warm are the castor-bean, sorghum, milo, feterita, Indian corn, garden balsam, portulaca, and four-o'clock.

For August and September sowing: Forget-me-not, pansy, cornflower, pink, and snapdragon.

Seeds that may be sown on well-prepared ground just before winter for early spring germination or on fall-prepared ground very early in the spring while the soil still freezes at night are the poppy, cornflower, cosmos, summer cypress, larkspur, snapdragon, snow-on-the-mountain, and sweet alyssum.

Flowers that are white or with pure white varieties: 4 feet, cosmos; 3 feet, dahlia and sweet-sultan; 2½ feet, clarkia, cornflower, larkspur, and scabiosa; 2 feet, baby's-breath, China aster, summer chrysanthemum, lupine, Japanese bellflower, snapdragon, garden balsam, and poppy; 1½ feet, godetia, four-o'clock, rose everlasting, and stock; 1 foot, candytuft, Iceland poppy, petunia, ageratum, lobelia, portulaca, sweet alyssum, and verbena.

Flowers having varieties mixed with white: 3 feet, dahlia; 2½ feet, salpiglossis; 1 foot, nemophila, pansy, petunia, and pink.

Flowers yellow or with yellow varieties: 4 feet, sunflower, feather cockscomb, and dahlia; 2½ feet, strawflower, sunflower, and zinnia; 2 feet, calliopsis, summer chrysanthemum, African marigold, snapdragon, and four-o'clock; 1 foot, calendula, Cape marigold, French marigold, Iceland poppy, California poppy, dwarf marigold, and portulaca.

Flowers having varieties mixed with yellow: 4 feet, dahlia; 2 feet, calliopsis, rudbeckia, salpiglossis, and summer chrysanthemum; 1½ feet, four-o'clock; 1 foot, dwarf nasturtium and pansy.

Flowers of orange color or with orange varieties: 3 feet, heliopsis; 2½ feet, zinnia; 2 feet, African marigold; 1 foot, calendula, Cape marigold, French marigold, and California poppy.

Flowers having varieties mixed with orange: 2 feet, gaillardia; 1 foot, dwarf nasturtium and French marigold.

Flowers lavender or with lavender varieties: 3 feet, basketflower and sweet-sultan; 2½ feet, larkspur; 2 feet, China aster; 1½ feet, candytuft; 1 foot, Drummond phlox, nemophila, and pansy.

Flowers having varieties mixed with lavender: 2½ feet, salpiglossis; 1 foot, pansy.

Flowers blue or with blue varieties: 2½ feet, cornflower and larkspur; 2 feet, lupine and Japanese bellflower; 1 foot, nemophila, ageratum, lobelia, verbena, and forget-me-not.

Flowers purple or with purple varieties: 3 feet, sweet-sultan; 2½ feet, clarkia and scabiosa; 2 feet, China aster; 1½ feet, stock; 1 foot, verbena.

Flowers having varieties mixed with purple: 2½ feet, salpiglossis; 1 foot, pansy.

Flowers pink or with pink varieties: 4 feet, cosmos; 3 feet, dahlia; 2½ feet, larkspur and zinnia; 2 feet, China aster, garden balsam, and poppy; 1½ feet, rose everlasting; 1 foot, Drummond phlox, pinks (including carnations), portulaca, and verbena.

Flowers having varieties mixed with pink: 3 feet, dahlia; 1 foot, pinks (including carnations).

Flowers salmon or with salmon varieties: 3 feet, dahlia; 2½ feet, clarkia; 2 feet, snapdragon and poppy; 1 foot, Drummond phlox.

Flowers having varieties mixed with salmon pink: 3 feet, dahlia; 1 foot, Drummond phlox.

Flowers scarlet or with scarlet varieties: 3 feet, dahlia; 2½ feet, scarlet sage and zinnia; 2 feet, snapdragon, poppy, and four-o'clock; 1 foot, Drummond phlox, pinks (including carnations), dwarf nasturtium, portulaca, and verbena.

Flowers having varieties mixed with scarlet: 3 feet, dahlia; 2 feet, snapdragon and poppy; 1 foot, Drummond phlox, pinks (including carnations), and dwarf nasturtium.

Flowers rose or crimson or with rose or crimson varieties: 4 feet, cosmos; 3 feet, prince's-feather, feather cockscomb, sweet-sultan, and spiderflower; 2½ feet, clarkia, cornflower, scabiosa, and zinnia; 2 feet, garden balsam, China aster, cockscomb, and lupine; 1½ feet, godetia, four-o'clock, globe amaranth, stock, and candytuft; 1 foot, Drummond phlox, petunia, and portulaca.

Flowers having varieties mixed with rose or crimson: 1 foot, Drummond phlox and petunia.

Plants used for their foliage or chiefly for it, the foliage being green unless otherwise noted: 4 feet, castor-bean (bronze and green separate), sorghum, feterita, milo, broom corn, and Indian corn; 3 feet, Joseph's-coat (red, yellow, and green mixed), love-lies-bleeding (red), summer cypress (pea green, turning crimson in late summer); 2½ feet, annual poinsettia (scarlet leaves in late summer) and snow-on-the-mountain (white-edged leaves); 1½ feet, Job's-tears; 1 foot, mignonette (a greenish flower grown for its sweet odor, but in its garden decorative value comparable to a plant grown for its foliage).

THE PRINCIPAL CHARACTERISTICS OF SOME ANNUAL FLOWERING PLANTS.

The following list presents in easily accessible form the principal characteristics of some annual flowering plants.

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.; also the page in this bulletin where a description of each plant and directions for its culture will be found.

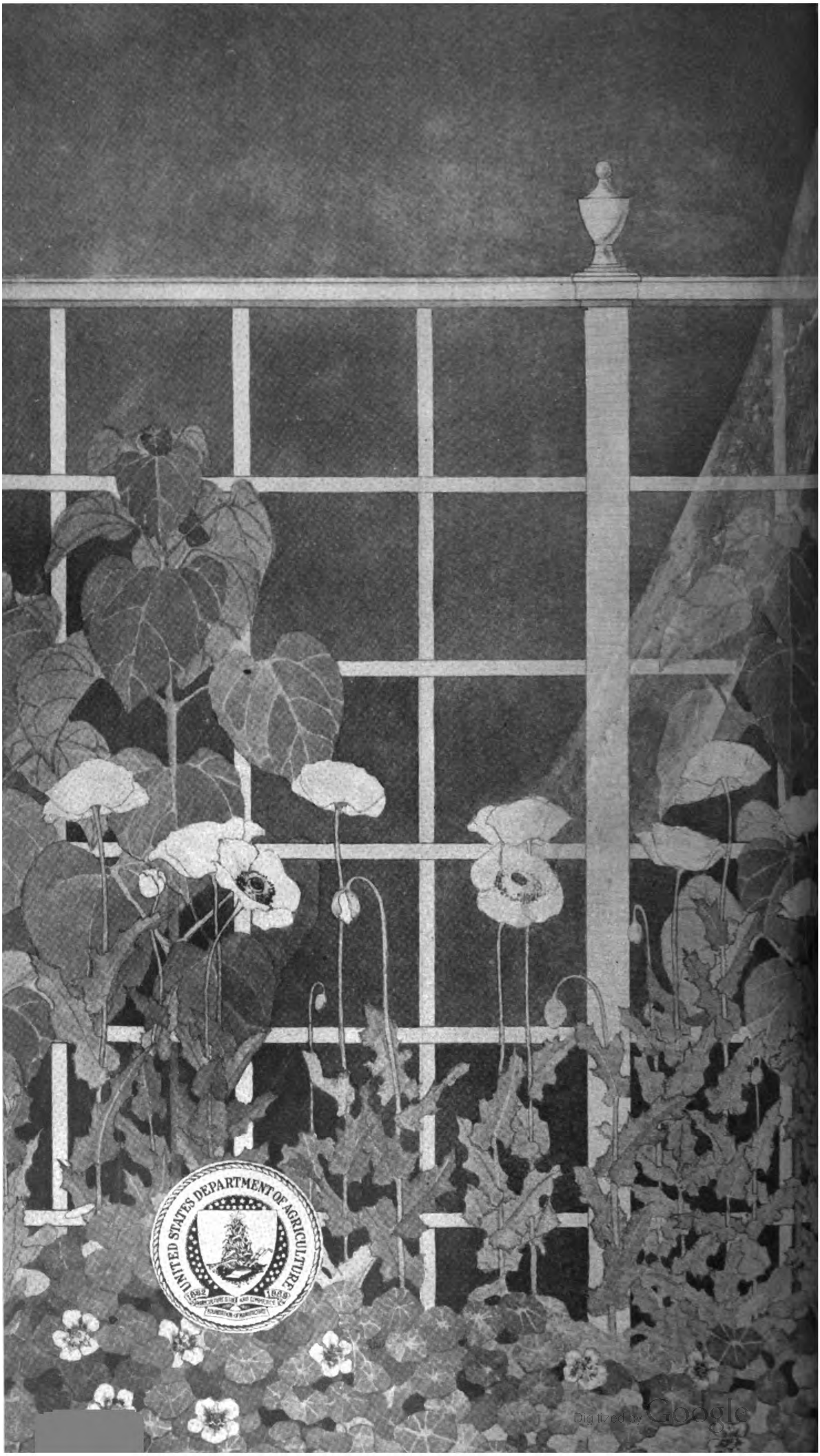
Common name.	Height of plant (feet).	Grown for flowers or foliage.	Color of flowers or foliage.	Preference for sun or shade.	Hardiness of plant.	Described on page—
Acroclinium. See Rose everlasting.						
African golden daisy. See Marigold, Cape.						
African marigold. See Marigold, African.						
Ageratum	1	Flowers	Blue, white, rose	Sun	Tender	67
Alyssum, sweet	1	do	White	do	Very hardy	72
Amaranth, globe	1½	do	Crimson or rose	do	Hardy	52
Amaranthus caudatus. See Love-lies-bleeding.						
Amaranthus cruentus. See Prince's-feather.						
Amaranthus tricolor. See Joseph's-coat.						
Antirrhinum. See Snapdragon.						
Aster, China	2	do	Purple, rose, white	do	Half hardy	40
Aztec marigold. See Marigold, African.						
Baby's-breath	2	do	White	do	Hardy	38
Bachelor's-button. See Cornflower.						
Balloonflower. See Bellflower, Japanese.						
Balsam	2	do	Rose, pink, white	do	Tender	48
Basketflower	3	do	Rose, lavender	Sun, slight shade	Hardy	28
Bean, castor. See Castor-bean.						
Bellflower, Chinese. See Bellflower, Japanese.						
Bellflower, Japanese	2	do	Blue, white	Sun, partial shade	do	46
Belvedere	3	Foliage	Pea green	Sun	Very hardy	31
Blackeyed-susan. See Rudbeckia.						
Blanketflower. See Gaillardia.						
Bluebottle. See Cornflower.						
Bluet. See Cornflower.						
Broom corn. See Corn, broom.						
Calendula	1	Flowers	Yellow, orange	do	Half hardy	57
California poppy. See Poppy, California.						
Calliopsis	2	do	Yellow, brown	do	Tender	40
Candytuft	1	do	Crimson, lavender, white.	do	Hardy	58
Cape marigold. See Marigold, Cape.						
Carnation, Marguerite	1	do	Scarlet, pink, white	do	do	61
Carpet of Snow alyssum. See Alyssum, sweet.						
Castor-bean	4	Foliage	Green, bronze	Full sun	Tender	22

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.; also the page in this bulletin where a description of each plant and directions for its culture will be found—Continued.

Common name.	Height of plant (feet).	Grown for flowers or foliage.	Color of flowers or foliage.	Preference for sun or shade.	Hardiness of plant.	Described on page—
Phlox, Drummond	1	Flowers	Red, lilac, buff, white.	Sun	Hardy	59
Phlox drummondii. See Phlox, Drummond.						
Pincushion flower. See Scabiosa.						
Pink, Chinese. See Dianthus.						
Pink, grass. See Dianthus.						
Pink, Japanese. See Dianthus.						
Pink, Scotch. See Dianthus.						
Platycodon. See Bellflower, Japanese.						
Plumed cockscomb. See Cockscomb, feather.						
Poinsettia	2½	Foliage	Green, turning to scarlet.	do	Tender	35
Poppy	2	Flowers	Scarlet, pink, white	do	Very hardy	49
Poppy, California	1	do	Yellow, orange	do	do	65
Poppy, Iceland	1	do	Yellow, orange, white.	do	Hardy	65
Poppy, Shirley. See Poppy.						
Portulaca	1	do	Reds and yellows	do	Tender	71
Pot marigold. See Calendula.						
Prince's-feather	3	do	Red	do	do	31
Ragged-robin. See Cornflower.						
Ragged-sailor. See Cornflower.						
Ricinus. See Castor-bean.						
Robin, ragged. See Cornflower.						
Rose everlasting	1½	do	Pink and white	do	Half hardy	54
Rudbeckia	2	do	Yellow, crimson	Sun, partial shade	Hardy	44
Sage, scarlet	2½	do	Brilliant scarlet	Sun	Tender	30
Sailor, ragged. See Cornflower.						
Salpiglossis	2	do	Purple, crimson, white.	do	do	47
Salvia. See Sage, scarlet.						
Salvia, scarlet. See Sage, scarlet.						
Scabiosa	2½	do	Crimson, rose, blue, white.	do	do	35
Scabious, sweet. See Scabiosa.						
Scarlet sage. See Sage, scarlet.						
Scarlet salvia. See Sage, scarlet.						
Scotch pink. See Dianthus.						
Shirley poppy. See Poppy.						
Snapdragon	2	do	Scarlet, yellow, white.	do	Very hardy	47

Snow-on-the-mountain	2	Foliage	Green leaves with white edge.	do	do	50
Sorghum	4+	do	Green	Full sun	Tender	26
Spiderflower	3	Flowers	Rose	Sun	do	31
Standing cypress. See Cypress, summer.						
Stock	1½	do	Crimson, purple, white.	do	Hardy	54
Strawflower	2½	do	Lemon, yellow	do	do	36
Sultan, sweet. See Sweet-sultan.						
Summer chrysanthemum. See Chrysanthemum, summer.						
Summer cypress. See Cypress, summer.						
Sunflower	4+	do	Yellow	Full sun	do	25
Sunflower, orange. See Heliopsis.						
Sun plant. See Portulaca.						
Sweet alyssum. See Alyssum, sweet.						
Sweet scabious. See Scabiosa.						
Sweet-sultan	3	do	Red, purple, lavender, white.	Sun	Half hardy	31
Sweet-william. See Dianthus.						
Tagetes. See Marigold, dwarf.						
Tasselflower. See Ageratum.						
Tom Thumb nasturtium. See Nasturtium, dwarf.						
Verbena	1	do	Scarlet, blue, purple, white.	do	Tender	74
Youth-and-old-age. See Zinnia.						
Zinnia	2½	do	Rose, scarlet, yellow, orange.	do	Hardy	37

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921



UNITED STATES DEPARTMENT OF AGRICULTURE

A 1.9:1171 Revise

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1171

GROWING ANNUAL FLOWERING PLANTS

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ANNUAL FLOWERING PLANTS are useful for quick though temporary effects and for flowers at a season of the year when blossoms on permanent plants are scarce.

Such plants in clumps in bays or pockets among shrubs or between herbaceous perennials make the beds and borders bright with bloom at a time when they might otherwise be dull and uninteresting.

Their quick growth makes them valuable in providing either foliage or flowers to fill temporary gaps in permanent plantings or to give a temporary effect where such planting does not exist. Several grow to a height of 6 feet or more, others hardly more than as many inches, while many are of intermediate height and show great variations in their habits of growth and in the color and character of their foliage.

Most of these annual plants are also valuable for supplying cut flowers for indoor decoration. They are of easy culture, profuse in bloom, have bright colors, and lend themselves readily to decorative arrangement.

Some of them can be sown in the open ground in the fall or in the early spring before freezing weather is past; others must be kept away from frost at all times. Some need to be sown where they are to bloom; others thrive better when transplanted one or more times. There are also differences in the kinds and conditions of soil, moisture, and light in which they will thrive best.

Coldframes and hotbeds are helpful in starting many of these plants, and for some of them they are essential to success, at least in the colder climates, if living-room windows or greenhouses are not available.

Washington, D. C.

Issued February, 1921
Revised October, 1929

GROWING ANNUAL FLOWERING PLANTS

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USES OF FLOWERING PLANTS

WHEN THE NEED for food, clothing, and shelter is reasonably satisfied, every human being, whether civilized or savage, begins to surround himself or herself with those things that please the eye. In addition, many people delight in the experience of making things grow. As a result of these impulses American home makers as a rule try to beautify the yards under their care.

The most permanent and satisfying results are usually those obtained by a lawn as a foundation, with trees making a frame for the house and giving grateful shade, accompanied by shrubs and permanent flowers to round off the corners and give an air of naturalness and homelikeness. In such a development there may be lacking during part of the season the brightness contributed by conspicuous flowers. Often this may be supplied by using annual flowering plants among the more permanent material, as most of them are gay with flowers at a season when most shrubs and perennials are not in bloom. When permanent plantings, especially shrubbery beds, are newly set, they often look thin and ragged. Here, again, interplantings of annuals (fig. 1) may be helpful, by filling the otherwise bare spaces with attractive foliage or with bright flowers or both.

Again, annual plants are useful on rented places where the tenant would seldom go to the expense of more permanent planting. They are quickly, easily, and cheaply grown, and their range of size and other characters makes it possible to secure temporarily many of the effects produced by the use of shrubs. (Fig. 2.) These results may be obtained more quickly than with shrubs, but they are transient, as the first frost or at least the first freeze obliterates all their effect, and the winter appearance is as bare and bleak as though nothing had been done. Such temporary planting should not be relied upon when conditions will at all warrant the use of more permanent material, but it should certainly be encouraged where planting for winter as well as summer effect is not possible.

The tall-growing full-foliage plants, like tall castor-beans, sunflowers, and the sorghums, when massed against buildings, fences, or in front of other obtrusive objects or objectionable views, serve as attractive and efficient temporary screens. Moderate-growing broad-leaved plants, such as the dwarf castor-bean, can be used with advantage as screens for driveways or walks by placing a mass of the plants in the bay of the walk or drive. Lower growing plants when massed against a background of taller growing annuals or shrubs, either against buildings or on boundaries, are more effective than when used in beds in the open lawn. The formal bed, in the shape of an oval, circle, or star, in the center of a lawn is generally more obtrusive than pleasing.

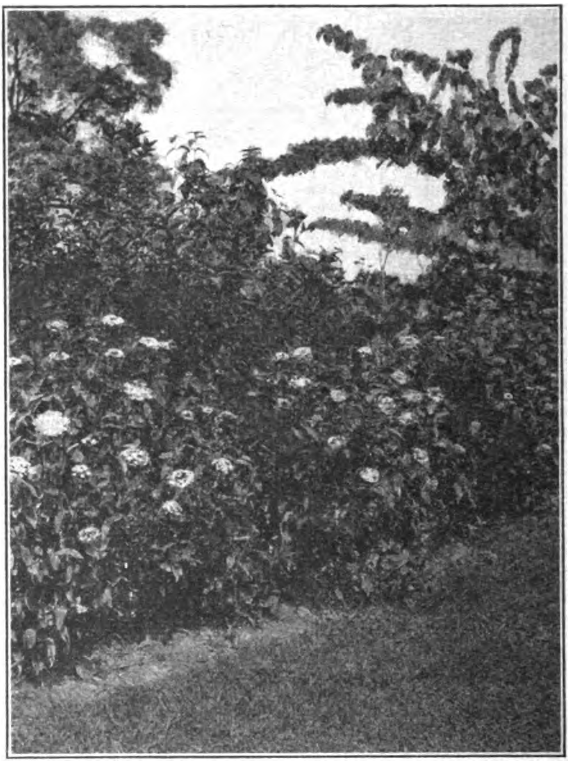

FIGURE 1.—Annual plants used among shrubs for a temporary effect

When annual plants are desired for use as cut flowers, the best arrangement is to plant them in an area set apart as a flower garden or to devote a portion of the vegetable garden to the purpose. When grown for cut blooms only, the most satisfactory and economical plan is to plant them in long rows, with ample space between the rows and the individuals in the rows. Unless the plants are given sufficient room for full development, the flowers that they produce will be inferior in size and form. To get the best results from plants to be used in this way, rich soil, ample space, and good culture are essential. They may be grown with horse cultivation as vegetables are grown.

If the flower garden is a distinct feature of the place and its mission is to furnish an attractive retreat, or a retreat and cut flowers, its general plan may be more pretentious; the straight rows may give place to irregular groups or masses, or even to formal beds and designs, so long as these are not made the leading feature in the general adornment of the grounds. In fact, such a garden should be more or less inclosed from the rest of the grounds by border plantings. These need not be over 3 feet high, or they may be of the tallest growing kinds. The design within the garden may be either formal or informal, with beds and walks of formal geometrical designs of either straight or curved lines, or both; or they may be irregular in the extreme with no set design. If the walks and beds are laid out in a formal fashion the plantings may be made in geometrical designs, as carpet bedding, if desired, or the design may be strictly irregular or informal. In the informal garden only irregular or informal planting is appropriate. A piece of ground irregular in outline or rough and uneven in surface lends itself more readily to the informal garden than to the formal. The paths in such a garden can be irregularly curving and can be made to present endless opportunities for exhibiting plant characteristics. On level ground with a regular outline the formal garden is appropriate and often the simplest to develop. By adopting the informal method of planting, however, the formal garden can be made to present anything but a stiff and formal effect. If the garden is to be permanent, the walks should be of a permanent and satisfactory material. Turf is probably the most generally satisfactory walk surface as well as the most economical. Brick, stepping stones, and gravel are also desirable under some conditions.

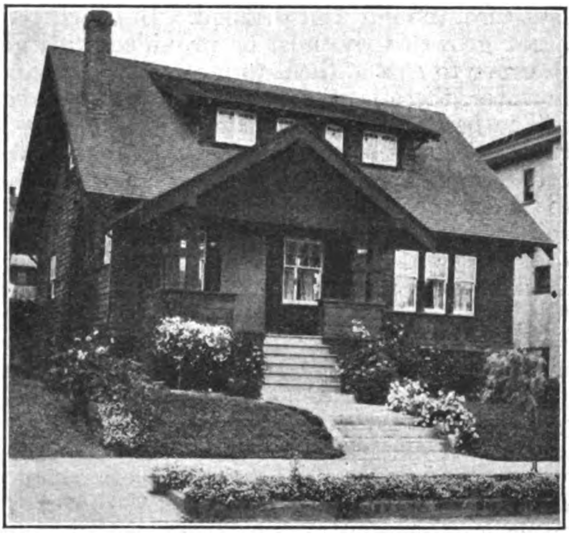

FIGURE 2.—Annual flowers used instead of more permanent material as the setting for a house

If a fixed design is adopted, the soil in various areas of the garden may be modified by the addition of sand, muck, or clay and by the use of plant foods to adapt particular areas to the needs of special plants. Those that enjoy a dry, sandy soil can be provided for, while those that thrive best in a heavy soil can also be accommodated. If, on the other hand, a less formal and fixed character in the garden seems desirable, the whole area may be annually spaded or plowed up, the walks given a new course, and the general scheme of planting changed. Such an arrangement will give variety and novelty to the garden and for most purposes will prove quite as successful as the more permanent arrangement. During wet periods. unless the soil is of a sandy character, the lack of an improved walk surface will prove a disadvantage.

Often annual plants can be used appropriately on the grounds about public buildings and in parks. Frequently the design of such grounds demands formal plantings, and many of the annual plants lend themselves admirably to such use.

GENERAL CULTURAL SUGGESTIONS

PREPARATION OF THE SOIL

Soil for the growing of annual plants needs to be well supplied with available plant food and should be reasonably retentive of moisture, though well drained. In short, because the plants make a quick growth they must be provided with good growing conditions in order to enable them to make that growth. Among these plants, however, there is a great difference in the requirements.

The best soil for most of these plants is a light, rich loam well supplied with rotted manure. A subsoil taken from the bottom of a cellar in excavating for a house is not suitable material upon which to depend as a satisfactory foundation for a flower bed. Where the soil is not naturally of the desired character, often much may be done to modify small areas to make them ideal for the culture of annuals. If the soil is thin and poor, a bed 2 feet deep can be excavated and filled with soil specially prepared for the plants it is intended to grow. More clay can be used in the soil for plants requiring heavy soil and more sand and leaf mold in the soil for plants requiring lighter soils.

An ideal soil for general purposes can be made from sods of bluegrass from a rather heavy clay loam rotted for a year, then mixed with equal quantities of rotted manure, leaf mold, and sand. The manure and sod can be rotted together for a year, if just as convenient. A specially prepared soil of this kind will probably not be benefited much by another coat of manure the second year, but after that it should have annual dressings. Where good garden soil or other rich soil of suitable texture is available, probably the more common practice is to make the bed of suitable depth and fill it with this soil well enriched with rotted manure. For permanent beds a careful preparation with good soil of proper texture is well worth the effort.

If for any reason such thorough preparation is not considered advisable, as on a place that may not be used for more than a year or two or on rented property where the tenure is regarded as comparatively temporary, the attempt to have annual flowers should not be abandoned, as even with much less preparation results may be obtained that are well worth the effort if the kinds of flowers grown are selected with consideration of the conditions that prevail.

Rotted manure, hen manure, prepared sheep or cow manure (obtainable from dealers in agricultural supplies), cottonseed meal, bone meal, or some similar organic manure, however, is almost essential to success. The value of these fertilizers is about in the order named.

There should be as much rotted cow manure, or even rotted horse manure, worked into the soil as can be done reasonably. Less hen manure should be used, as it is several times richer than cow or horse manure. The prepared cow and sheep manure can be used at the rate of 1 pound for 3 square feet, and the cottonseed meal and bone meal at the rate of 1 pound for 5 square feet. All these materials should be thoroughly worked into the soil. They will not bring satisfactory results, however, unless the ground is reasonably good to start with, especially as to texture.

When larger areas are used for flowers, as in a special garden that can be handled with a plow, like a large vegetable garden or part of the vegetable garden, soil-improvement crops, like crimson clover and vetch in winter or cowpeas in summer, may be used to enrich the soil and thus prepare it for another season's crops. It is possible sometimes to adapt some of these soil-improvement crops to the smaller areas of flower beds, although it is seldom advisable, as the limited quantity of fertilizing materials usually needed can ordinarily be provided.

WATER

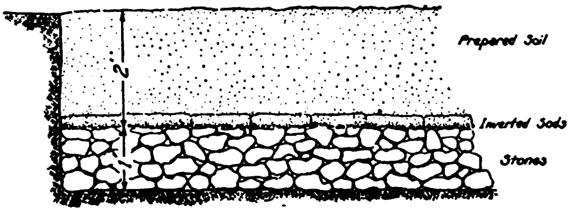

FIGURE 3.—A bed specially prepared for plant growth where the normal drainage is inadequate

A proper water supply is essential. The provision of a deep soil of proper texture well enriched with organic manure makes a water-holding reservoir that acts something like a sponge in its ability to supply water for the plants. Such a soil will absorb a large amount of water whenever given an opportunity and will give it up readily to the plants as it is needed. On the other hand, provision must be made so that when such a soil has absorbed all that it is capable of properly holding, the surplus will drain away. If the surplus water does not naturally pass away freely, then artificial drainage must be provided. In poorly drained soils, beds specially prepared, as already described, should be excavated 3 feet deep instead of 2 feet, and in the bottom a layer of stone should be placed, covered by inverted sods, which in turn should be covered by 2 feet of soil. (Fig. 3.) This layer of drainage should be given some suitable outlet to carry off any water that might otherwise collect in it. This would preferably be by a drainpipe taken to a sewer or to some suitable outlet. A stone drain may be used, but it is likely to become clogged.

Throughout much of the United States the natural rainfall on a bed well prepared, as already described, would be sufficient in most seasons. Beds close to a house, so that much of the rain is kept off by the building, need to have the natural rainfall supplemented by occasional waterings. Irrigation is necessary in dry climates and also in moist climates in unusually dry seasons, also on sandy or other unusually dry soils. The amount and frequency of watering will depend upon the dryness both of the atmosphere and of the soil.

A well-prepared retentive soil 2 feet deep would probably not require watering oftener than once a week, except possibly in the driest parts of the country, where the evaporation is excessive. Gravelly or sandy soils, especially if not well provided with organic matter, may require a thorough watering every other day. The watering should be done as infrequently as the soil and the climatic conditions will permit. Only experience can teach the best method. Too frequent watering is as bad as too long an interval between waterings. If watered too often the surface soil is kept moist and the root growth is encouraged near the surface. A day's neglect or unusual drying conditions will dry the feeding ground of the roots and kill them. But if the roots are required to go deeper by permitting the surface to become dry for 2 or 3 inches between waterings, there will be less danger of unfortunate results from unusual conditions or a slight deviation from the regular schedule of watering.

STARTING THE PLANTS

Ornamental annual plants can be started readily from seed in the spring and will give bloom or satisfactory foliage effects the same season. Nearly all of these can be started in the open ground over at least a large part of the United States, and will give the desired results before they are cut off by frost. In order to get a longer season of effect from the plants many of them are usually started under glass, or early plantings are started that way. In the more northern sections of the country some kinds must be started in this way in order to have a season long enough to mature; others so that they may become established before the coming of dry or hot weather, which would be injurious to the young plants but would not affect established ones.

Seed sowing and germination.—All of the plants mentioned in this bulletin can be propagated from seed. In some cases, however. the seeds require special care in order to insure a good stand of plants, and it is for that reason that the particular methods necessary for that purpose are described.

A few of these plants must be sown where they are to mature, as they will not stand being moved. Many may be sown where they are to grow, though most of them are helped by one or two transplantings. Because better plants are obtained by transplanting. most annuals are sown in seed beds and moved to their permanent places. Such seed beds should be in well-prepared mellow soil. preferably somewhat protected from drying winds. If the soil is not mellow, the seedlings, especially from the smaller seeds, will have trouble breaking through any crust that may form, especially if moisture conditions are not exactly right. Protection from winds also helps to maintain uniform moisture conditions. The timely use of a watering can is often a great help in promoting germination. but care should be taken not to use it too much. Seed beds require frequent light waterings rather than the infrequent drenchings best suited to more mature plants.

Seeds may be sown either broadcast or in rows. The inexperienced gardener should plant seeds in rows, especially slow-germinating seeds, as quick-starting weeds may be more readily recognized and removed with less danger of disturbing the germinating seeds.

Weeds starting near the seed row may be removed at once with great care or may be left until the seedlings are well sprouted. The dates of sowing the different kinds of seeds will be mentioned under the respective headings in connection with the discussion of other special cultural requirements.

The germination of seeds depends upon a proper degree of heat, moisture, and oxygen from the air. Some seeds germinate best under a high temperature (80° to 90° F.), while others do best at a low temperature (40° to 60° F.). For most seeds, however, a soil temperature of 65° to 70° F. with an air temperature of 60° F. will prove very satisfactory for germination. Strange as it may seem, nature maintains conditions during the early part of the growing season approximating those above specified. But naturally the high temperatures are much later in the season than the low ones. In order to obtain the higher temperatures early in the season a greenhouse, hotbed, coldframe, or a sunny kitchen window must be used.

Seeds in most cases grow best when the moisture in the soil is slight rather than excessive. A good test for moisture is to take a handful of soil and compact it gently in the palm of the hand by closing the fingers. If when released the soil remains solid and retains the impressions of the hand, it is too wet; but if when released it springs back and slowly crumbles or parts, it is in ideal condition for seed sowing. Such soil is well aerated, while the soil containing an excess of moisture has the air largely replaced by water.

The seed bed should be carefully guarded against extremes of moisture. It should not be allowed to get too wet and remain in that condition for any length of time; neither should it be allowed to get too dry. In the open these conditions are not likely to occur during a normal season. However, there are frequent exceptions. If the seed bed is too wet, little can be done to overcome the bad results, but if drought occurs irrigation will remedy the evil. Under artificial conditions, such as are obtained in a greenhouse, hotbed, or coldframe, the moisture content of the soil of the seed bed can be very carefully controlled. The confined atmosphere of such a structure prevents rapid or excessive evaporation, while any loss of moisture from the soil can be made good by watering. On a small scale the same results can be approached by placing a pane of glass over the receptacle in which the seeds are sown.

Slight variations in the temperature of the soil in which seeds are sown are usually a benefit rather than a hindrance to germination. With the grasses and clovers and probably with practically all other plants, germination is more rapid and more complete in seeds subjected to alternations of temperature than in those kept under constant temperatures. Under normal conditions the warming of the soil during the day and the cooling at night furnish sufficiently wide variations. While these variations are less easily controlled than the variations in moisture, yet in structures such as hotbeds and coldframes the change from day to night temperature will be perceptible.

Seeds in order to germinate promptly must be placed under conditions that will enable them to take up moisture readily, and at the same time they must have a temperature that will be congenial to the young plant when it appears. The soil is the medium by which heat and moisture, under normal conditions, are transferred to the seed. In order to insure a quick exchange of moisture from the soil to the seed, the soil should be carefully firmed or compacted about the seed. By compacting the soil about the seed the capillary power of the soil is increased and the soil moisture is more quickly brought to the seed. In outdoor operations large seeds may have the soil compacted about them by tramping the row with the feet, while fine seeds may be treated by resting a board over the row and walking upon it from end to end. In hotbeds, greenhouses, and coldframes the compacting of the soil is usually accomplished by the use of a float, which consists of a piece of board about 6 inches wide and 9 or 10 inches long, with a handle attached, as shown in Figure 4.

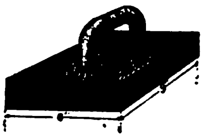

FIGURE 4.—A float for firming the soil

For all conditions save in the open, seeds may be sown in seed pans or in flats, as shown in Figure 5. These boxes can be very conveniently and cheaply made from the pine boxes largely used for packing canned goods, soap, or other merchandise, usually 9 or 10 inches deep, which is sufficient to permit cutting them with a ripsaw into three sections, each about 3 inches high. The top and bottom of the box will each make a complete flat, while the middle section will be a frame which can be provided with a bottom by the destruction of a box for three sections; i. e., four boxes will furnish nine complete flats or by using other lumber for the bottom of the middle section each box will make three flats. Seeds may also be planted directly in the soil of the hotbed, coldframe, or in that upon the greenhouse bench as well as in the garden. Here, too, they may be sown broadcast, but it is preferable to sow in rows.

In covering seeds the rule under artificial conditions is to bury the seed to the depth of its greatest diameter, while outdoors they are usually covered about three to five times their diameter. With seeds the size of a grain of wheat it is safe generally to plant them 1 inch deep, and for those the size of beans, 2 inches deep. Small seeds, the size of those of petunia or tobacco, should be scattered over the surface and the soil compacted with a float.

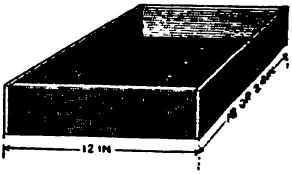

FIGURE 5.—A flat

Transplanting.—The young seedling plants should be transplanted as soon as the first true leaves are formed, so that they will stand at some distance from one another. Preliminary to transplanting, the seed bed should be wetted thoroughly an hour or so before digging the plants, so that they can be removed from the soil without breaking the roots. The beds, flats, or pots into which the transplanting is to be done are previously prepared with soil that is moist but not wet; that is, it must spring apart again promptly if squeezed in the hand. Holes for the plants are satisfactorily made with a short stick three-eighths or a half inch in diameter and sharpened at one end. A flat stick sharpened at one end, as for example, a 6-inch pot label, makes an excellent implement for digging the seedlings. The seedlings should be carefully loosened in the soil so that they may be lifted out with any soil that may possibly adhere to the roots, then be placed in the prepared holes at about the depth they were before, and then the earth should be pressed about the roots firmly but gently. A frequent practice is to dig the plant with the right hand, lift with the left one, and press the soil about the roots with the right one. Sometimes the pot label is used to open the holes as the planting is being done, one motion of the label opening the hole and another motion pressing the soil about the roots after the plant is placed in position.

The plants should be thoroughly but carefully watered at once and then should be kept somewhat shaded until root contact has become reestablished. Longer shading is required in hot, dry weather than in cool, partially cloudy weather. In dark, cloudy weather shading may often be omitted. Watering must receive especial attention until growth starts.

For small, rather slow growing plants, such as pansies, 1 inch apart each way will afford ample room; with most plants 2 inches each way will be best; but with robust growing plants, like the castor-bean, 4 inches will not be too much. With such vigorous growing plants, however, it is best to place the seeds directly in pots or cans in order to prevent disturbing the roots of the young seedlings as well as to afford them ample space. If ordinary pots are not available, paper pots may be obtained cheaply, or old strawberry boxes may be used. Transplanting has a tendency to make the plants stocky and provides opportunity for the development of an extensive root system.

HOTBEDS AND COLDFRAMES

The pleasure derived from floral decorations depends not only upon the perfection of the flowers but upon having a continuous display throughout the season. With most of the garden annuals early bloom can not be secured if seed sowing in the open must be relied upon exclusively. Fortunately, gardeners have devised cheap and efficient means of lengthening the growing season several weeks by the use of coldframes and hotbeds. In the latitude of Washington, D. C., the time of sowing seed requiring the higher temperatures for germination can be advanced from May 1, the normal date of sowing in the open, to March 1, a gain of two months. Seed sown in a gentle hotbed at this date will give plants which, if properly handled, will forward the season of bloom two weeks or more.

HOTBEDS

Hotbeds are usually constructed in one or the other of the following ways:

Temporary hotbeds.—A temporary hotbed may be made by using fermenting stable manure from grain-fed horses, preferably that with a small quantity of straw or litter in it. The manure should be placed in a broad, flat heap and thoroughly compacted by tramping. A heap 8 or 9 feet wide and any multiple of 3 feet in length, with the manure 14 to 16 inches deep, will give sufficient heat for the latitude of New York City and of Kansas City, Mo. Farther north, the heap should be made deeper and broader. Upon the surface of the manure heap a frame made like that shown in Figure 6 will afford ample space for the development of the plants within. The backboard of this frame is usually 12 inches wide and the front 8 inches, and the two are connected by a tapered board 12 inches wide at one end, 8 inches wide at the other, and 6 feet in length. The back and front of the frame are made in multiples of 3 feet in length, with an inch added for each division space between sash, which is provided for by the use of a T-shaped piece let into the frame to stiffen it and serve as a guide for the sash. The manner of making the guide as well as its appearance when in place is shown in Figure 6. A cross section is illustrated by Figure 7. If severe weather is likely to occur during the time the hotbed is in use, the frame should be banked with manure to give additional heat and protection. After placing the frame upon the manure heap, about 3 inches of good garden loam should be scattered uniformly over the area inclosed by the frame. Place the sash in position immediately and allow the bed to heat up. Do not plant any seed in the bed until the temperature begins to subside, which will be in about three days after the sash are put in place. When the temperature has fallen to 85° or 90° F. planting may be safely begun.

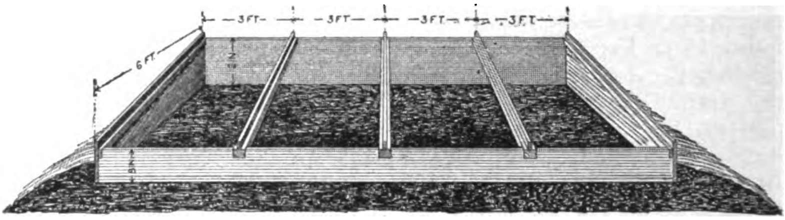

FIGURE 6.—A frame to carry the sash of a hotbed or coldframe

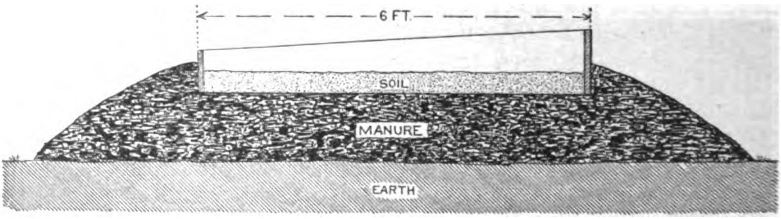

FIGURE 7.—Cross section of a temporary hotbed

Permanent hotbeds.—A permanent hotbed may be so constructed as to be heated with fermenting manure or by radiating pipes from the dwelling or greenhouse heating plant. For a permanent bed, in which manure is to supply the heat, a pit 2 to 2½ feet in depth, according to the latitude in which the work is to be done, should be provided. The sides and ends may be supported by a lining of planks held in place by posts 4 feet apart, or, better still, a brick wall 9 inches thick, as shown in Figure 8, may be used. In either case the pit lining should come flush with or above the surface of the soil.

The site for the pit should be on naturally well-drained land, and a tile drain from the bottom of the excavation should be provided to prevent water from accumulating in the pit and stopping the fermentation of the manure during the period the hotbed is in use.

Standard hotbed sash are 3 by 6 feet in size, and the interior crosspieces for holding the sash are 1 inch wide. The pit, therefore, should be some multiple of 3 feet 1 inch in length less 1 inch, and the width should be the same as the length of the sash—6 feet. The plank frame or brickwork of the pit may be extended above the surface of the ground sufficiently to allow for placing the sash immediately upon these permanent structures, or a frame such as is described in connection with the construction of a temporary hotbed (fig. 6) may be used. In the fall the pit should be filled with leaves or straw and covered with loose boards or shutters to prevent it from becoming filled with snow and ice in the North, so that it may be ready for use early in March there, or in January or February farther south.

Sash.—Hotbed sash should be constructed of white pine, cypress, or redwood, and the sash bars should run in one direction only and that lengthwise of the sash. The bars may be braced through the middle by a transverse bar placed through the long bars below the plane occupied by the glass. The two ends of the sash should be made of sound timber 3 inches wide at the top and 4 inches wide at the bottom end, mortised to receive the ends of the sash bars and with a tenon at the ends to pass through the side pieces, which should be 2½ inches wide.

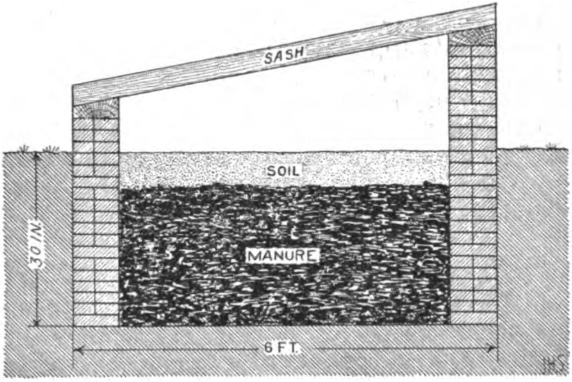

FIGURE 8.—Cross section of a permanent hotbed or pit

Glazing.—Placing the glass in the sash is one of the most important operations in the construction of a hotbed and is also a factor that largely determines the success or failure of the bed. The glass should be bedded in putty, i. e., the rabbet in the sash bar that is made to carry the glass should be filled with soft putty, and the glass, crowning side up, pressed firmly into the bed of putty and securely fastened with shoe nails or wire brads. Glazing points are not sufficiently secure. The first glass to be placed in any frame is a bottom light, i. e., the pane nearest to the front or lowest side of the hotbed when the sash is in place. The next light should be bedded in the same manner as the first and so placed as to lap about three-sixteenths of an inch over the top edge of the one first placed, like shingles on a roof. Brads should be driven below the lower corners of the second pane in order to prevent it from slipping down over

Half-hardy plants are those that can be sown in the open ground a week or two before the last frost may be expected, or that can be started under glass and transplanted to the open ground while there may still be danger of slight frosts, but which do better with temperatures above the frost point. Seeds of such plants may be sown about the time leaves begin to appear on the trees that put out their foliage earliest.

Tender plants are those that are checked or stunted by an approach to frosty conditions and are injured by even the slightest frost. Many of them must be started under glass, especially in the North, in order to have a sufficiently long season in which to develop. Most of them are natives of tropical or subtropical countries and require a long season for growth. Their seeds should not be put in the open ground until all danger from frost is past, which is about the time that white-oak leaves are the size of squirrels' ears. Tender plants should not be taken from frames and put into their permanent places until 10 days later than this.

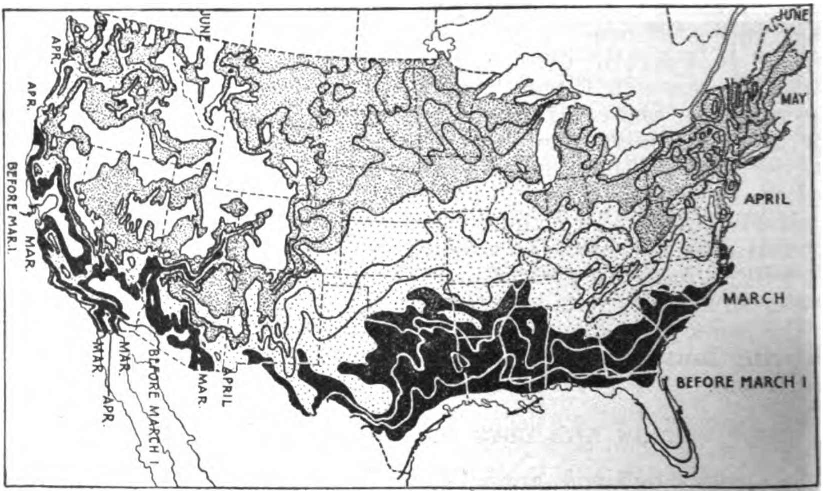

FIGURE 9.—Outline map of the United States showing the date of the average occurrence of the last spring frost

From the foregoing it will be seen that the time of planting the different flowers will depend on the forwardness of the season, especially as regards freezing and frost. These conditions vary greatly, the map (fig. 9) giving some idea of the approximate date of the last frost at different points in the United States. In the map the shaded portions are those in which the last frost occurs in March or in May, the lines in them indicating intervals of 10 days. The lines in the unshaded portions similarly indicate 10-day intervals. From the eastern foot of the Rocky Mountains westward only the monthly intervals are attempted to be shown, as frost conditions there are governed almost entirely by elevation rather than by latitude, which makes it almost impossible to give any satisfactory idea within the limits of this map.

Most of the annual flowering plants are so vivid in their colors and when planted are used in such large masses that more care is probably required to avoid bad color combinations than with other classes of plants. When used in clumps in shrubbery beds so that there is other foliage to separate the colors, there is much less danger of getting bad combinations than when large masses of different kinds of annuals are used in a garden or in a single border. The colors found in the different varieties of a single species usually will not clash. As a guide in selecting flowers that may be safely used near one another, the color diagram shown as Figure 10 is presented. The colors opposite one another on the diagram are safe to use together, as well as those close beside one another, but those at rignt angles to one another—that is, the intermediate ones—are not safe to be used except by those who have made an extended, careful study of color combinations.[1]

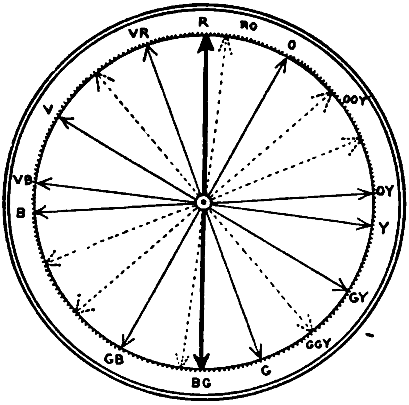

FIGURE 10.—Diagram showing good and bad color combinations. Colors immediately adjacent to one another or opposite one another are appropriate for use together. Those between should be separated by masses of foliage or by white flowers. B = blue, G = green, O = orange, R = red, V = violet, Y = yellow

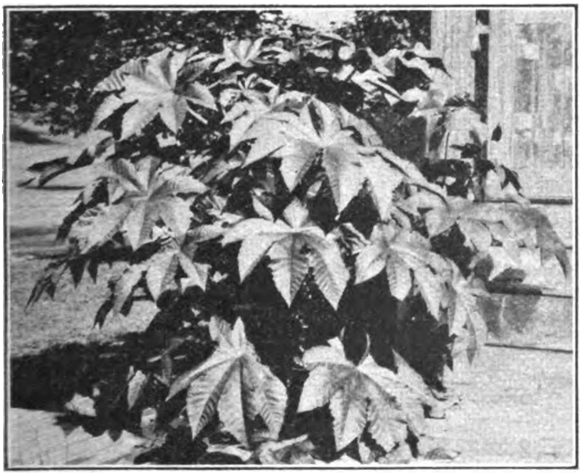

FIGURE 11.—Castor-bean

BACKGROUNDS AND SCREENS

Among annual flowering plants there are a few that are excellent for backgrounds and screens. Among these are castor-beans, cosmos, sunflowers, sorghums, feterita, milo, broomcorn, and even Indian corn.

Castor-bean.—The castor-bean or castor-oil plant[2] is especially valuable because it is one of the few annuals that can be used to produce a semitropical effect. (Fig. 11.) Its rapid growth, large size, and easy culture make it valuable as the central object in groups where rich, luxuriant growth is required. The big lobed leaves with variety of color of the different sorts, ranging from green to deep bronze, are of value in giving contrast, and when used in combination with cannas, caladiums, coleus, or scarlet sage most striking effects can be produced. As a background for lower growing plants, the castor-bean has no equal among garden annuals. Only the annual climbing vines when provided with suitable supports equal it as a low screen. It can be used with good effect in groups, as masses along shrubbery borders, as belts for covering and shutting out undesirable views, and singly against buildings or to fill gaps in newly planted shrubbery.

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[1] A suggestion as to the reasons for this is given in Farmers' Bulletin 1087, Beautifying the Farmstead.

[2] *Ricinus communis* L.

This plant loves a rich soil, plenty of moisture, full sunlight, and great heat. In the North it is most satisfactory when started in a gentle heat four or five weeks before the last frost. A hotbed, greenhouse, or living room can be used for the purpose. As soon as the first true leaves have formed, the young plants should be pricked out into small boxes or pots, or they may be started in strawberry boxes or in paper pots, with one seed to a pot. They should be kept growing slowly until all danger of frost has passed, when they may be transferred to the open. After transplanting the young plants it is desirable that they have sufficient room to prevent them from growing too tall and consequently from losing their lower leaves. They should be from 3 to 6 feet apart, depending on the variety.

If planted in the open ground about the date of the last frost, or 10 days before it would be safe to set plants in the open, they will make a growth of 4 to 6 feet in 10 weeks. The varieties range in height from 3 to 15 feet and have leaves of corresponding size.

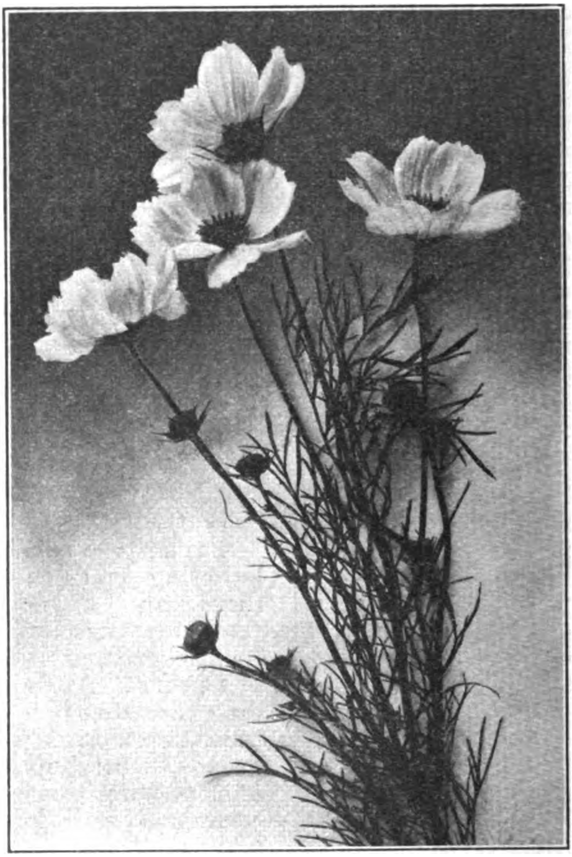

FIGURE 12.—Cosmos

Cosmos.—Cosmos[3] is now one of the notable fall flowers. It is a vigorous tall-growing annual, yet its bright, bold flowers have a daintiness and airiness that is heightened in effect by the feathery green foliage. (Fig. 12.) It is most effective when planted in broad masses or along background borders against evergreens or fences at some distance from the house and the garden walks. The white, pink, and rose-colored daisylike flowers are borne in great profusion and come at a season when they are very acceptable. There are also double varieties. In the North, seed started in the house at the same time as castor-beans will give plants 3 or 4 feet in height by September. Because of the robust habit of the plant, the young seedlings should be thinned to 18 inches apart when grown on moderately good soil. Sowing the seed late and in poor soil will dwarf the plants. In the climate of Washington, D. C., of St. Louis, Mo., and farther south they perpetuate themselves by self-sown seed. These volunteer plants can be utilized for early bloom.

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[3] *Cosmos bipinnatus* Cav.

Cosmos is especially desirable for the warmer parts of the country, where it grows and blooms luxuriantly with little care. In the North only the earliest varieties are likely to mature soon enough to bloom. As the plants approach maturity it is well to give them some support, as they are liable to be bent over by the wind.

Sunflower.—Sunflowers[4] are tall-growing bright-flowered annual plants that have not received the attention they deserve. The tall-growing large-flowered sorts, as well as the dwarf many-flowered varieties (fig. 13) are useful when skillfully employed in mixed plantations with other herbaceous annuals. The golden yellow disks are like sunbursts among the shrubbery. The tall habit and dense foliage of some varieties make them suitable for backgrounds and screens. Because of their long stems and extraordinary lasting qualities they are of value as cut flowers.

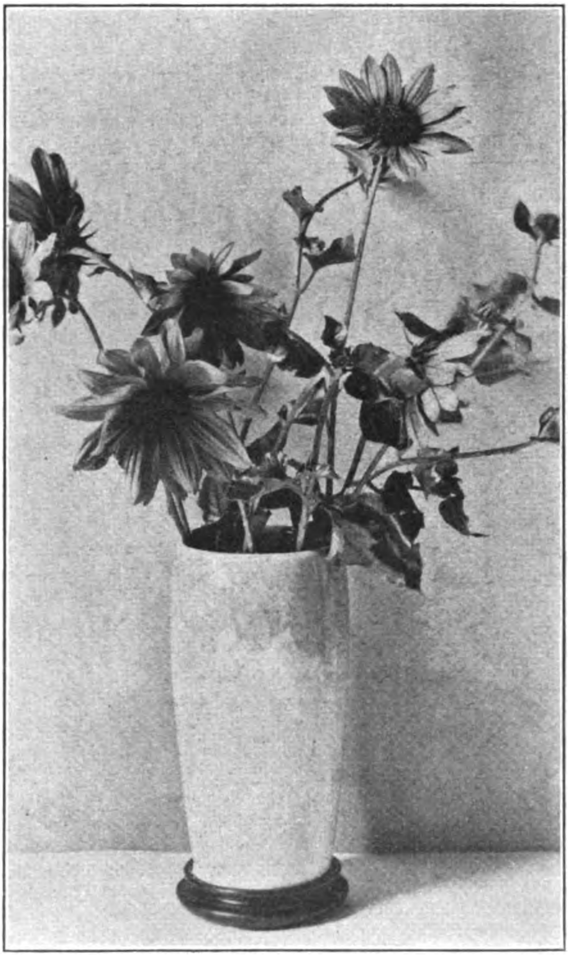

FIGURE 13.—Sunflower

Sunflowers are of easy culture. The seed should be planted in the open garden in spring at about the time that corn or beans are planted, or about a week after the average last frost, and the plants should be thinned to stand from 2 to 4 feet apart, depending upon whether it is a dwarf or a tall-growing variety. The height ranges from 1 to 10 feet with the different varieties, while the habit of growth, character of foliage, and number of flowers vary correspondingly.

Cornlike plants.—Sorghum,[5] feterita,[5] milo,[5] broomcorn,[5] Indian corn,[6] may all be considered together, as their treatment and use in landscape planting is similar. Used with castor-beans and sunflowers they may be very effective, as their foliage and habit of growth contrast strongly with the foliage of the plants already described. They may also be used effectively in clumps and groups of their own or in borders. They need other plantings at their base; otherwise the stems will be bare and unsightly. They can be used effectively among thick-foliaged shrubs that have not yet grown sufficiently to take all the ground. They should be planted among plants with whose foliage they form a contrast and above which their plumelike blooms, and in some cases fruit, can show effectively.

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[4] *Helianthus annuus* L. and other species.
[5] Cultivated forms of *Holcus sorghum* L.
[6] *Zea mays* L.

Varieties vary in height from 3 to 10 feet. They are sun and warmth loving plants and should all be planted about the time Indian corn is planted, or when danger from frost is past. They are easily grown where the weather is warm.

Canna and elephants-ear.—In addition to the annual plants mentioned, cannas and eleplants-ears are vigorous-growing plants, valuable for their foliage, that are grown from roots and tubers, respectively. The first cost of these is much more than for seeds, but where a greater variety is desired they are valuable. By digging the roots before freezing weather and storing them in a cellar where the temperature is maintained well above freezing, they can be kept from year to year.

PLANTS GROWING 3 OR MORE FEET HIGH

There are a large number of annual plants of intermediate height, many of which are very striking. Some of the taller of these that grow 3 or more feet high are the basketflower, feather cockscomb, dahlia, Josephs-coat, larkspur, love-lies-bleeding, heliopsis, princesfeather, sweet-sultan, spiderflower, and summer-cypress. Of the plants already described the castor-bean, sunflower, and feterita have dwarf varieties of about this height.

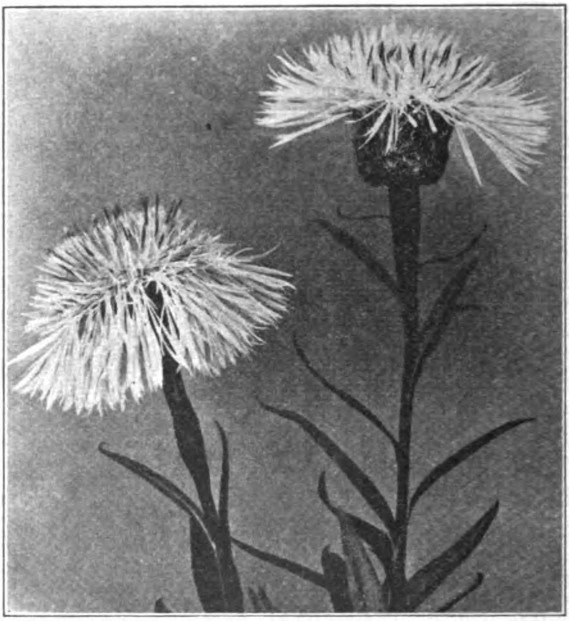

FIGURE 14.—Basketflower

Basketflower.—The basketflower[7] is a hardy native thistlelike flower (fig. 14), growing to height of 3 feet, bearing large rosy lavender flowers. It should be sown in the open ground in early spring about as soon as the ground is in condition to work. It does well when sown where it is to bloom, but can be successfully transplanted. It prefers cool weather and is not as easy to grow as many other annuals.

Feather cockscomb.—The feather cockscomb,[8] sometimes called plumed cockscomb, but more commonly known as celosia or *Celosia plumosa*, is a plumelike and graceful tender annual (fig. 15), growing 3 feet tall, with showy flowers, either crimson or yellow. The plumes may be cut before they are fully ripe and may be dried in the house for winter bouquets. Seeds may be sown out of doors after danger from frost is past, or they may be sown earlier under glass. They prefer a light soil, not too rich, but grow easily almost anywhere.

Dahlia.—The dahlia[9] has many double and some single forms in reds and yellows. They are usually grown from rootstocks, but they can be grown from seed readily by those who have had a little experience with plants. The double-flowered varieties must be sown as early as April for satisfactory bloom the first year, while the single varieties may be sown as late as July 1. Dahlias must be grown where frost can not reach them, so in the North it is necessary to start the double-flowered ones under glass.

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[7] *Centaurea americana* Nutt.

[8] *Celosia argentea* L.

[9] *Dahlia rosea* Cav.

As soon as the tops are hurt by frost the roots should be dug on a warm sunshiny day so they will not be chilled, and then they should be stored in a warm cellar with as much dirt as possible about them. A place suitable for cannas and sweet potatoes is satisfactory for dahlias. Another method is to store them in boxes of sand. New plants may be started the next season from these roots.

Josephs-coat.—Josephs-coat[10] is an easily grown upright plant reaching heights of 3 or more feet, whose attractiveness is due to the brilliant red, yellow, and green foliage. It likes warmth and sunshine and plenty of room, with the soil not too rich. It will not stand frost, so it must be started either late out of doors or under glass if results early in the season are desired. It can be started six weeks before danger of frost is past and may be transplanted once or twice before setting it in the open ground.

Love-lies-bleeding.—Love-lies-bleeding[11] (fig. 16) is another easily grown, rather upright annual with drooping blood-red foliage. It should be handled in the same manner as Josephs-coat and responds to the same cultural conditions.

Heliopsis.—Heliopsis,[12] sometimes miscalled orange sunflower, is a hardy perennial with pale orange-colored flowers that will bloom the first year from seed. It is easily grown and will attain a height of 3 to 4 feet. Seeds may be sown early out of doors about the time the last frost may be expected.

Princesfeather.—Princesfeather[13] is an upright annual, 3 to 4 feet tall, with dark red feathery flowers. Its culture is like that of Josephs-coat, already discussed, and is adapted to the use of a beginner.

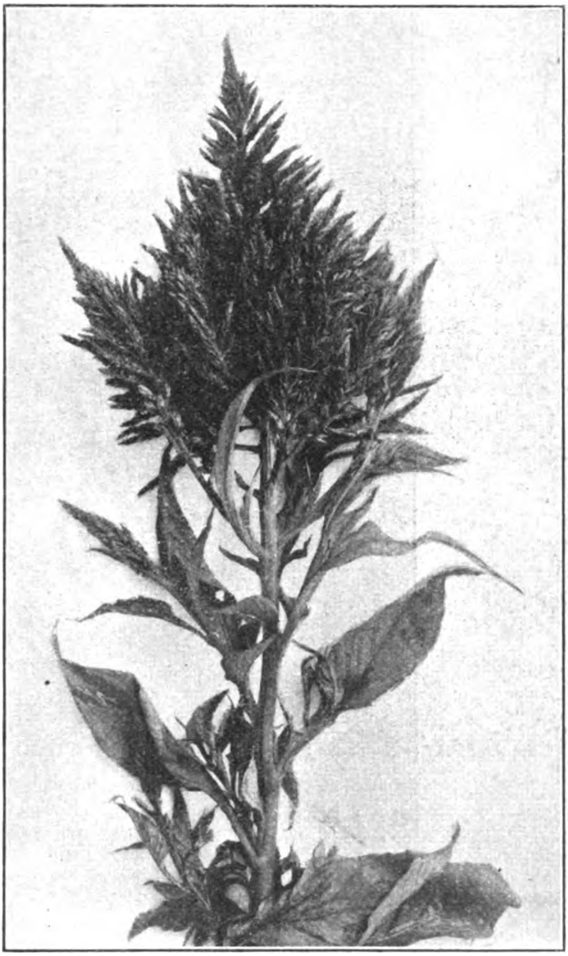

Figure 15.—Feather cockscomb

Sweet-sultan.—Sweet-sultans,[14] or royal sweet-sultans, are handsome sweet-scented, thistlelike, hardy annuals growing to a height of over 3 feet, with red, purple, lavender, and white varieties. They are useful both for cutting and in borders. They are sown early in the spring for the best results, so that they will get an early start and bloom before hot weather. They will stand some frost.

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[10] *Amaranthus gangeticus melancholicus* Voss.
[11] *Amaranthus caudatus* L.
[12] *Heliopsis helianthoides pitcheriana* Fletcher.
[13] *Amaranthus hypochondriacus sanguineus* Hort.
[14] *Centaurea moschata* L.

Spiderflower.—The spiderflower[15] (fig. 17) grows to a height of 3½ feet and forms large, loose heads of rose-colored flowers borne well above the foliage for a long season. The seed should be sown in the open ground soon after the weather is settled, or two or three weeks before the last frost may be expected. The plant is of easy culture.

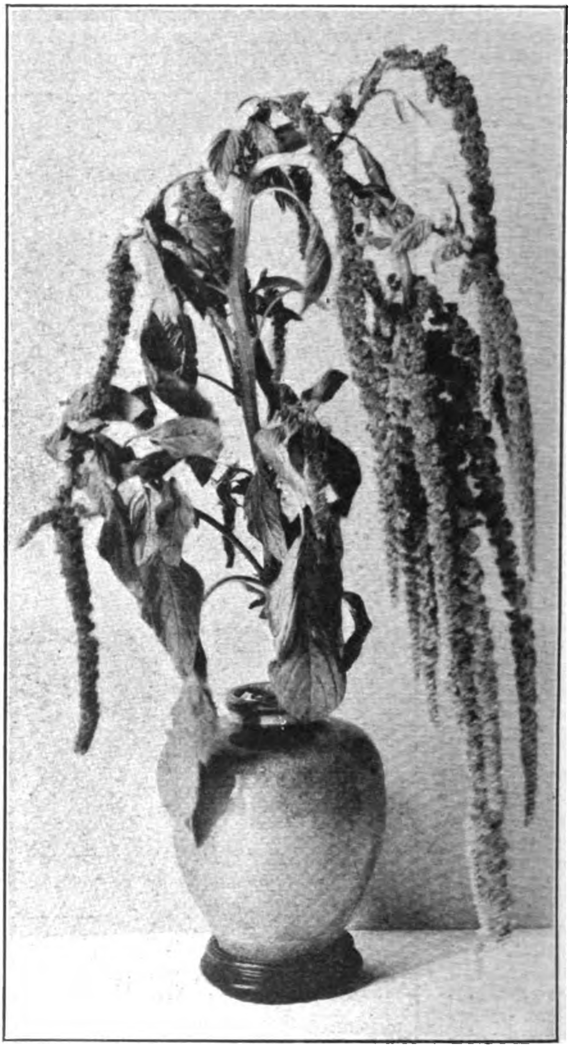

FIGURE 16.—Love-lies-bleeding

Summer-cypress.—Summer-cypress,[16] also called standing cypress and Mexican flame plant, is a useful plant for a pale-green mass effect or for formal effects. (Fig. 18.) Belvedere[17] is a similar plant of more erect habit. The foliage is fine and light in color, but very effective when used in masses. When grown with plenty of room they form uniform oval symmetrical specimens 3 or more feet high. For specimen plants they should be set at least 4 feet apart; for a hedge, 18 inches or 2 feet apart. Summer-cypresses do not thrive in shade, the part that is shaded failing to grow, thus making the plants one sided. On the other hand, their growth is stimulated by the close proximity of an electric arc light. As they approach maturity the whole plant gradually turns crimson, later becoming brown and unattractive on the approach of frost. The bloom is inconspicuous, but the plant seeds freely, and the second season the ground will be covered with seedlings, which, however, are readily killed by hoeing. Seed may be sown thinly in the open ground early in the spring. Culture is of the easiest.

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[15] *Cleome spinosa* Jacq. [16] *Kochia trichophylla* Stapf. [17] *Kochia scoparia* Schrad.

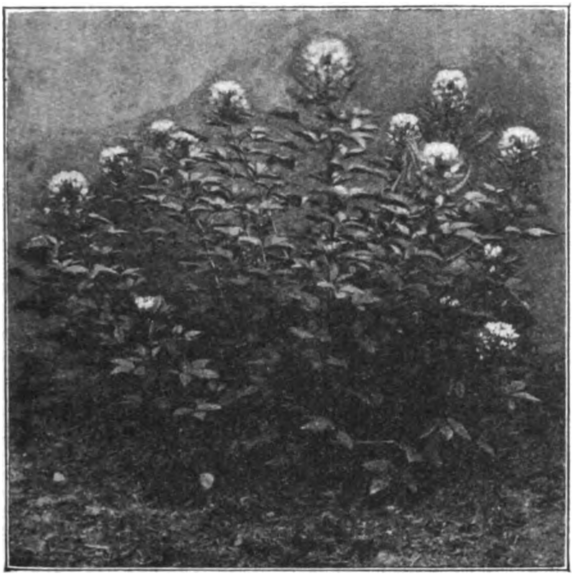

FIGURE 17.—Spiderflower

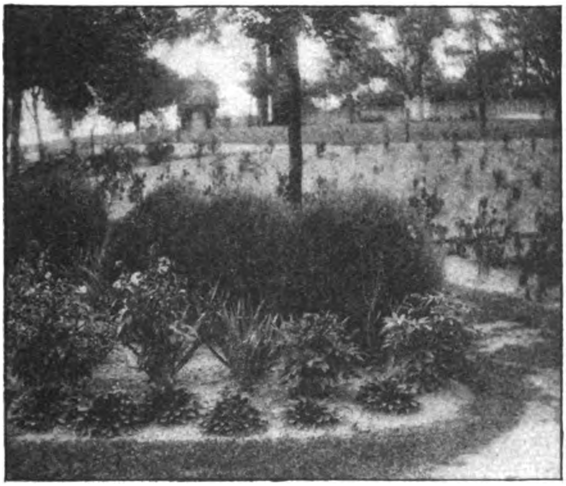

FIGURE 18.—Summer-cypress on the back of a bed

PLANTS GROWING ABOUT 30 INCHES HIGH

Plants that grow about 30 inches high are clarkia, cornflower, larkspur, scabiosa, annual poinsettia, scarlet sage, strawflower, and zinnia. Some of the varieties of sunflowers are also as small as this.

Clarkia.—Clarkia [18] is one of the prettiest of hardy native annuals. It comes from west of the Rocky Mountains. Its freedom of blooming, with the variety and brightness of its white, salmon, or scarlet flowers, makes a bed of these plants an attractive sight. They are useful, too, for hanging baskets, for vases, as edging plants, for low massing, or for borders. The seed should be sown outdoors in early spring, and the plants should be grown in partial shade. The clarkias thrive in a warm light soil, and their period of bloom is from midsummer to late autumn. The average height of the plant is 2 to 2½ feet.

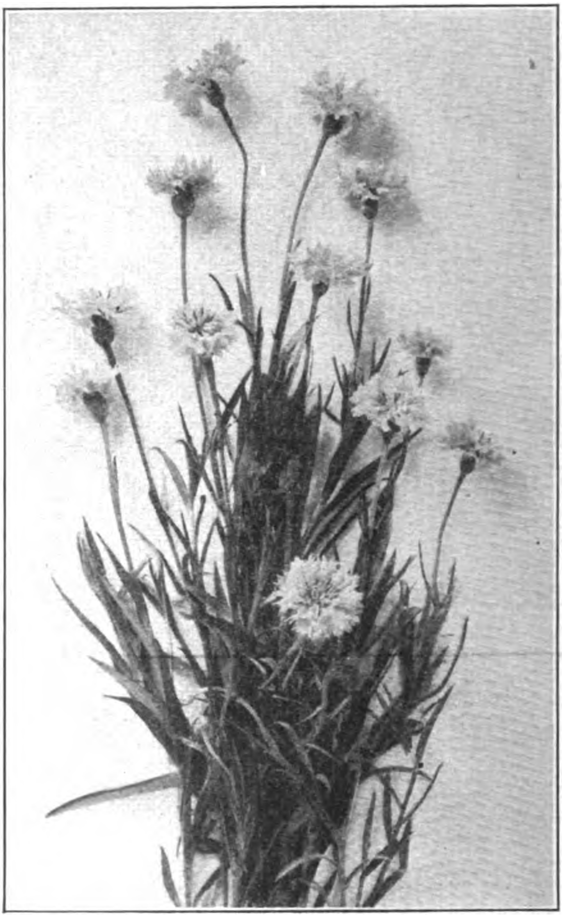

FIGURE 19.—Cornflower

Cornflower.—The cornflower [19] (fig. 19) is also known as bachelor button, bluebottle, ragged sailor, kaiserblume, and sometimes erroneously as ragged robin and bluet. These bright-flowered plants are of a hardy nature, requiring simple culture, yet they are among the most attractive and graceful of all the old-fashioned flowers, bearing freely blue, white, or rose-colored blossoms. When placed in water after cutting the flowers increase in size. The seeds of these annuals should be sown in the fall or in the spring from the time the ground is fit to work until the last of May in the North and the last of June in the South. They may be started earlier under glass. The young plants should be thinned to 4 to 6 inches apart. They thrive well on all moderately rich garden soils. When once established they will usually reseed themselves year after year.

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[18] *Clarkia pulchella* Pursh, *C. elegans* Douglas.

[19] *Centaurea cyanus* L.

Larkspur.—The larkspur[20] is especially valuable because of its rich blues, as blue is a comparatively rare color among our cultivated plants. There are also

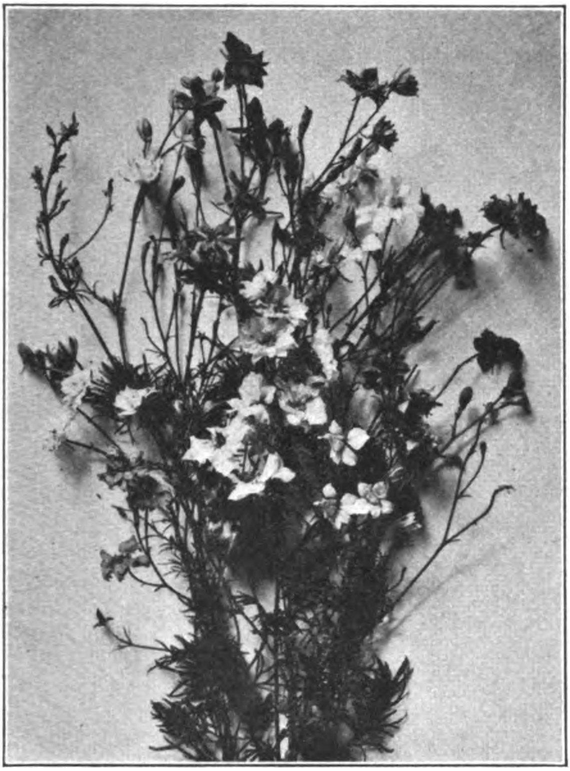

FIGURE 20.—Larkspur

vhite varieties and a red species. The taller growing annual varieties reach height of 30 inches and are valuable for bedding and borders as well as for ut flowers. There are other varieties only about 18 inches high (fig. 20) that re even better for bedding purposes. There are both single and double forms f the annual larkspurs. In addition to these there are many perennial arieties that will bloom the first year from seed, so they can be used as anuals with reasonable satisfaction. These vary in height from 18 inches to 5 eet. Larkspurs are easily grown, but do best in a rather cool, moist soil. he seeds of the annuals may be sown in the open ground either in late fall or n spring, preferably the former, so they will be ready to germinate early in he spring. In the South the perennial varieties may be handled in the same ay. As the seedlings grow they should be thinned to stand from 6 to 18 nches apart, depending upon the variety. Among the annual larkspurs there re in addition to the blue varieties white, buff, rose, pink, and similar shades.

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[20] *Delphinium ajacis* L., *D. consolida* L.

These may all be sown separately or in mixture with entirely satisfactory results.

From Norfolk northward the perennial varieties need to be started under glass in order to bloom the first year from seed. The young plants can be transplanted into flats before they are an inch high, being placed 3 to 4 inches apart, and by gradually hardening them off they can be set in the open ground before corn-planting time. These plants can be set 6 to 8 inches apart the first year, but need to be farther apart the following year.

Some species bloom both early and late, and the blooming period of all can be prolonged by removing the withered flower stems promptly.

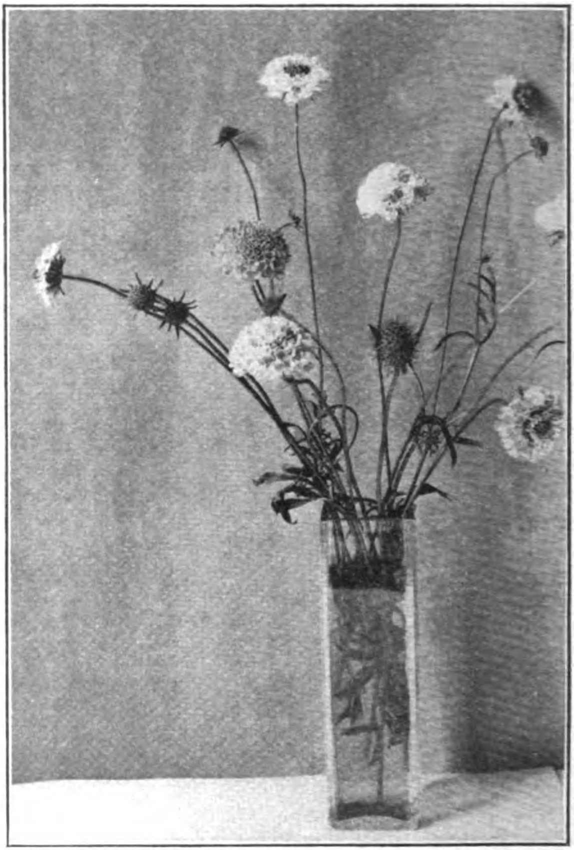

FIGURE 21.—Scabiosa

Scabiosa.—Scabiosa,[21] often called mourning bride, pincushion flower, and sweet scabious, is an easily grown old-fashioned half-hardy annual (fig. 21) that is very attractive and satisfactory both for cutting and for borders and beds. The flowers, which vary from white through rose, crimson, and blue to almost black, are borne on long stems and keep a long time either on the plant or when cut. The seed should be sown in the open ground after danger from hard frost is past, and the plants will bloom in about 12 weeks. There are also hardy perennial kinds.

Annual poinsettia.—The annual poinsettia[22] (fig. 22), Mexican fire plant, painted spurge, or painted leaf, is a handsome green-leafed plant that about midsummer changes the color of several of the leaves at the ends of the branches to scarlet. As the plant is naturally much branched and bushy, it makes a great show. It attains a height of 2 to 3 feet. Seed should be sown in the open ground when freezing weather is past.

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[21] *Scabiosa atropurpurea* L.

[22] *Euphorbia heterophylla* L.

Scarlet sage.—Scarlet sage,[23] or scarlet salvia, is a standard bedding plant that keeps the garden bright with color until late in fall. This plant lends itself to many uses (fig. 23); it makes a good pot plant, does well in window boxes, and is useful for cutting, to give color. Its commonest use, however, is as a hedge or border plant, giving long broad bands of vivid scarlet. On account of its very striking color, caution needs to be observed in using it in this way. It can be most effectively used in small clumps among or against masses of green.

Seeds should be sown in window boxes or frames six weeks before the last frost and the plants set outdoors after all danger from frost is past; or the seeds may be sown outdoors, if the place is protected from heavy rains and strong winds, about the date of the last frost, so the seed will not germinate until after all danger of frost is over. The plants grow and bloom profusely in any light rich soil.

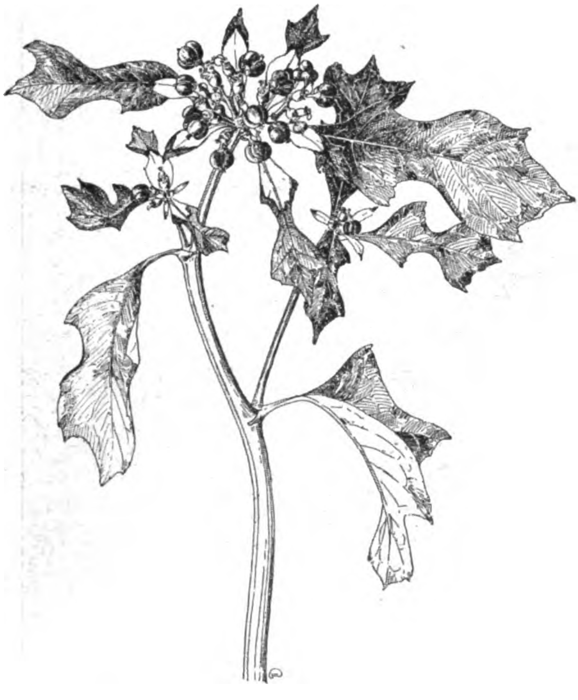

FIGURE 22.—Annual poinsettia

Besides the scarlet sage, there are blue salvias, which are perennials, most of them being hardy. Both the tender and hardy perennial sorts bloom the first year, and all may be treated as annuals.

Strawflower.—The strawflower[24] is an attractive, easily grown, hardy annual, bearing double lemon and yellow flowers an inch and a half across (fig. 24). These plants are very effective for beds and borders, and the flowers may be cut and dried for winter bouquets. They succeed in any good garden soil, but respond to plenty of fertility. The seed may be sown in the open ground as soon as all danger of freezing is past. They do better, however, if transplanted once or twice. They should have plenty of room to develop, not being planted closer than 12 inches apart. They grow to a height of 30 inches.

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[23] *Salvia splendens* Ker. [24] *Elichrysum bracteatum* Andr. (Helichrysum).

Zinnia.—The zinnia,[25] sometimes called "youth and old age," is easily grown from seed sown in the open ground. When sown as soon as the ground is fit to work, the plants will bloom abundantly and continuously through the entire season. (Fig. 25.) Of late great improvements have been wrought in both the color and the form of the flower. The colors are white, yellow, orange, pink, rose, and scarlet. During the month of August zinnias are at their best. To obtain large flowers and a profusion of bloom the plants must be given ample room for full development as well as an abundant supply of food. Strong rich soils suit them. If the seeds are sown in a dwelling house or in a hotbed and the young plants are pricked out once or twice before being placed in their permanent situations, more satisfactory results will be obtained than from outdoor-sown seeds, unless equal care in thinning or transplanting is given. The plants can be used for groups, beds, borders, garden lines, and summer hedges. Their average height is 2½ feet, ranging from 2 to 3 feet.

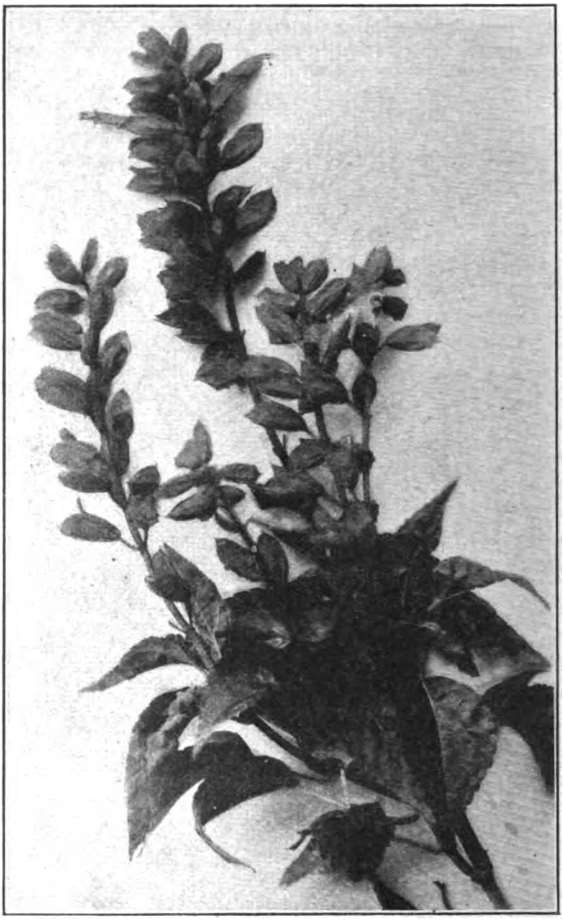

FIGURE 23.—Scarlet sage

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[25] *Zinnia elegans* Jacq.

PLANTS GROWING ABOUT 24 INCHES HIGH

Several of the annual flowering plants that grow about 2 feet high are very useful for both ornamental planting and cut flowers. Among these are babysbreath, calliopsis, China-aster, summer chrysanthemum, cockscomb, rudbeckia, gaillardia, lupine, African marigold, balloonflower, salpiglossis, and snapdragon. The garden balsam, Shirley poppy, and snow-on-the-mountain are other plants of this height desirable for ornamental plantings but not suitable for cutting. Of the plants already discussed the larkspur, scarlet sage, and sunflower have varieties that are about this height.

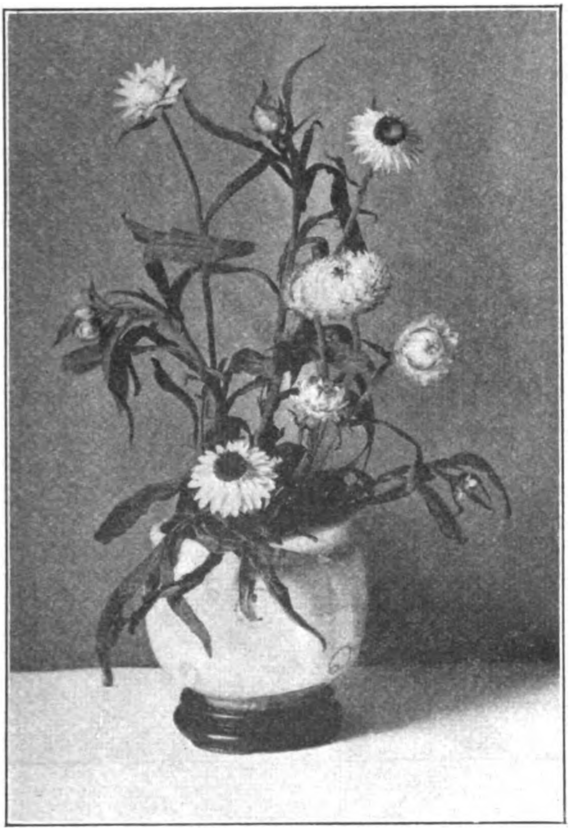

FIGURE 24.—Strawflower

Babysbreath.—Babysbreath[26] is a dainty free-growing white-flowered plant that is much used to put with cut flowers, to lighten the effect. It also tends to lighten the effect if used in mass plantings. The different species vary in height from 8 or 10 inches to 2 feet. The seed should be sown in the open ground as soon as freezing weather is well past.

Calliopsis.—Calliopsis[27] is the name given to the ornamental annual plants of the genus Coreopsis. They have showy, graceful, long-stemmed flowers (fig. 26) well suited for bouquets and yet so borne as to make very effective border or bedding plants. The principal color is a deep yellow, which is combined in some varieties with rich maroons and in others with browns. Varieties vary in height from 9 inches to 2 feet. They are of the easiest culture.

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[26] *Gypsophila elegans* Bieb. and *G. muralis L.*, annuals, and *G. paniculata L.*, a perennial.

[27] *Coreopsis tinctoria* Nutt., *C. basalis* Blake (*C. drummondii*), *C. nuecensis* Heller (*C. coronata*).

Seeds may be sown under glass or in the open, but they should not be sown outdoors before the last frost. They may be sown under glass two months before this. Seeds sown in the open in May will usually give an abundance of flowers from August till frost. After transplanting or their final thinning the plants should be 10 inches apart each way.

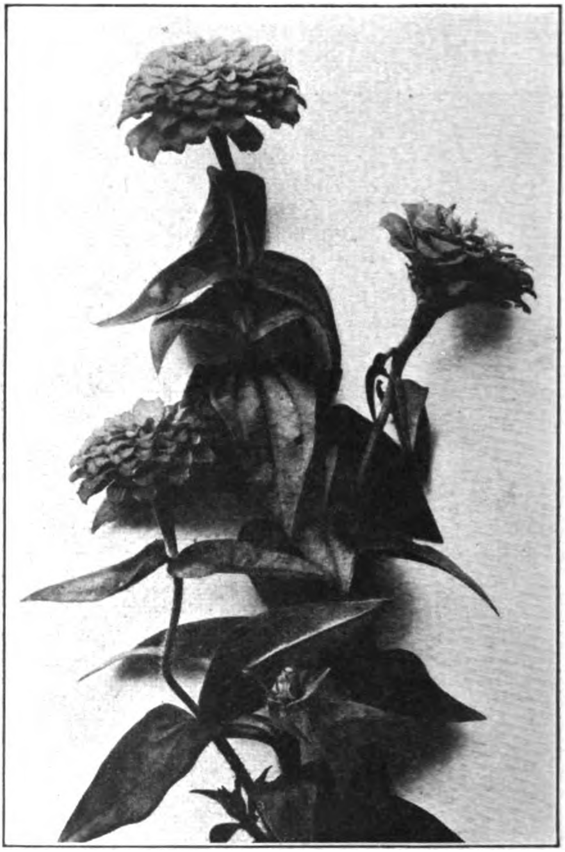

FIGURE 25.—Zinnia

The perennial form, *Coreopsis grandiflora*, will bloom the first year if the seed is sown early.

China-aster.—The China-aster[28] is one of the most desirable of the annual flowering plants. The variety in its size, color, form, and season of blooming makes it most satisfactory for supplying cut flowers; in fact, many of the improved sorts produce flowers equal in form and size to some of the better sorts of chrysanthemums. The range of color is one of its chief merits. Strange as it may appear, the plant world is not very well supplied with blue flowers possessing characters that suit them to domestic or commercial uses. In the China-aster, however, are found many shades of lavender and purple, and for this reason, if for no other, they should prove an attractive decorative plant. There are also white, pink, and rose-colored varieties. The habit of growth adapts the China-aster to close planting for cut bloom, for window boxes (fig. 27), and also for bedding. It should not be confused with the attractive native hardy perennial asters, which are robust tall-growing plants well adapted for use in an herbaceous border where late bloom and careless effects are desired. The more compact-growing large-flowered China-asters are most desirable for cut blooms, while the tall-growing open wild aster[29] is most useful in wild garden or for screens. The vigor and ease of culture of the China-aster are factors that contribute to its popularity.

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[28] *Callistemma chinensis* Skeels (*Callistephus chinensis*).

Plants from seed sown in the open ground in May and given sufficient moisture bloom abundantly in September and October, when the flowers are seen at their best. For July and August blooms the seeds should be sown in March or April. When frosts occur during this season the planting will need to be done in a coldframe, a spent hotbed, or in pots or boxes in a living room. Cover the seed about half an inch deep with rich light soil, and when the plants have three or four leaves transfer them to thumb pots or to other boxes, setting the plants about 2 inches apart each way. After all danger of frost is

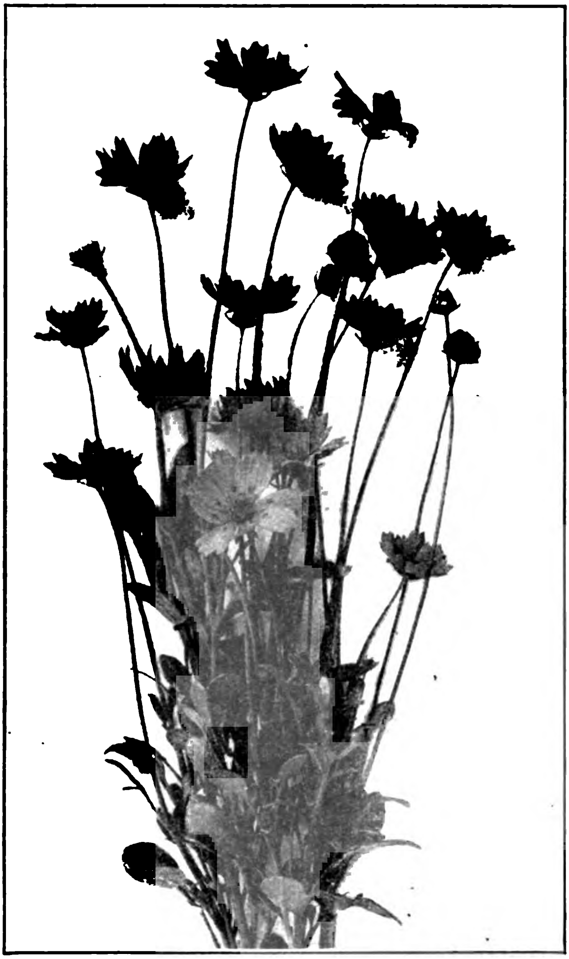

FIGURE 26.—Calliopsis

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[29] *Aster novae-angliae* L.

past, transplant the plants to their permanent home, where they should stand about 18 inches apart each way in well-prepared beds. Fresh manure or manure used in too large quantities sometimes proves injurious to them. Only thoroughly composted manure mixed with the soil is safe for these plants. Small quantities of air-slaked lime or of fresh wood ashes stirred into the surface of the beds are beneficial. When given plenty of water and rich, fine soil, China-asters can be grown into beautiful pot plants.

In some localities and during some seasons the China-aster is seriously attacked by the so-called black potato beetle, or blister beetle,[30] an insect that feeds upon the partly developed buds, causing them to develop, if at all, into deformed, irregular blossoms. In such localities these flowers can be successfully grown under screens of mosquito netting or other thin cloth.

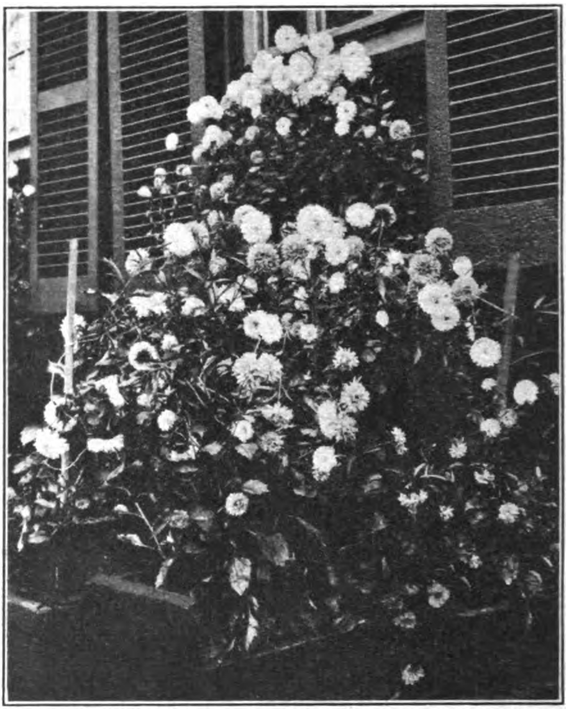

FIGURE 27.—China-asters in window boxes

Chrysanthemums.—The chrysanthemums, like the pinks, comprise some of the most valuable of the commercial florists' products, both hardy perennial and annual flowering plants. The large-flowered types of chrysanthemums, which each fall produce such gorgeous shows in the stores, florists' establishments, and conservatories, are not hardy, and since they are treated as greenhouse plants by the florists, they are only mentioned in this list. The class of hardy chrysanthemums, which should be more commonly seen in every flower garden and are known as pompons, are simply noted to give proper relation to the annual chrysanthemums, which are the subject of this sketch.

Summer or annual chrysanthemums[31] bloom most satisfactorily if the seeds are sown early in a hotbed or coldframe and the young plants transferred to the open as soon as the soil has become sufficiently warm to keep them growing without check, or two weeks after the usual date for the last frost. If started in a hotbed the young plants should stand 10 to 12 inches apart when set in their permanent locations. Somewhat less satisfactory results can be obtained by sowing the seed in the open where the plants are to bloom, at or just before the date of the last frost. The seedlings should be thinned to stand at least 8 inches apart. If the same care in regard to disbudding and pinching back is taken with the annual plants as with the large-flowered perennials, the work will be rewarded by the greatly increased size of the usually white or yellow flowers. (Fig. 28.)

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[30] *Epicauta pennsylvanica.*

[31] *Chrysanthemum carinatum* Schousb, *C. segetum* L., *C. coronarium* L.

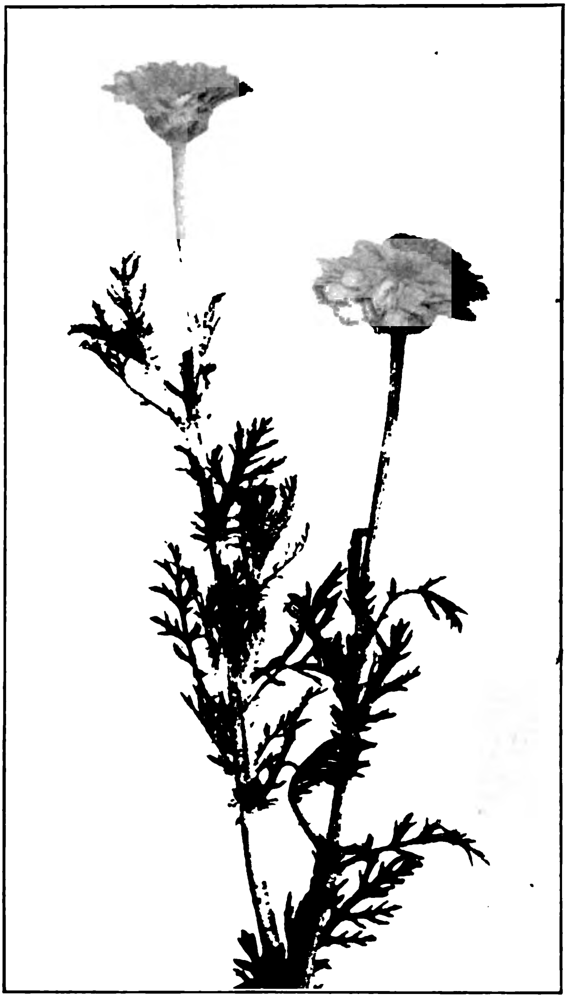

FIGURE 28.—Summer chrysanthemum

The hardy chrysanthemums[32] will bloom a little the first year from seed if started early, but the plants will not be compact and bushy until the second year. They should be started early in March, and where freezing is liable to occur after planting they should be started under glass in order to give them time to mature before frost.

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[32] *Chrysanthemum leucanthemum* L., discussed in Farmers' Bulletin 1311, Chrysanthemums for the Home.

Cockscomb.—Cockscombs[33] are prized and planted as an easily grown odd and picturesque decorative feature of the garden. (Fig. 29.) The tall ones form striking groups, and when interspersed with other lower growing plants in a border they produce a pleasing contrast, while the dwarf varieties make novel and attractive borders. There are bright red and crimson varieties. The young plants can be grown from seeds sown in gentle heat four weeks before the last frost and transplanted to the open ground when danger of frost is past; or about the time the last frost is expected the seeds may be sown in the open where the plants are to stand. Transplanting into rich soil as the combs begin to form makes the flower heads much larger. They are bright from midsummer until frost.

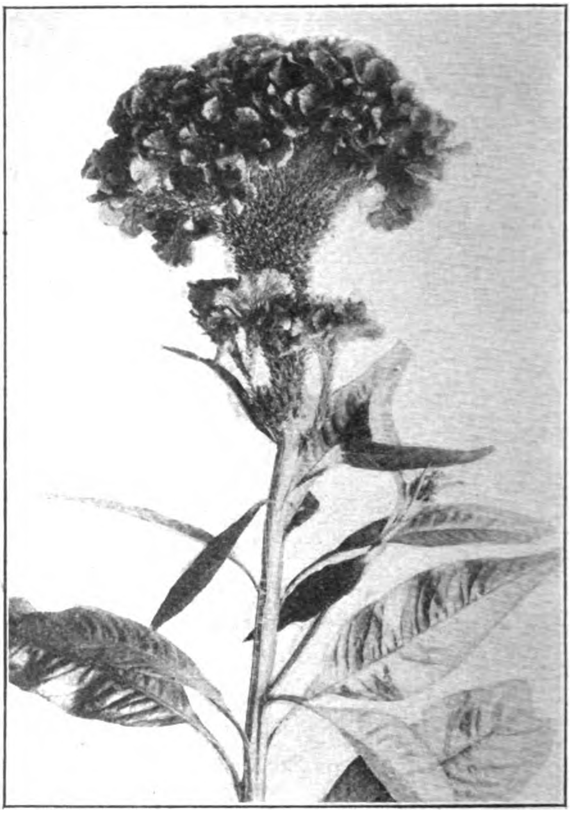

FIGURE 29.—Cockscomb

Rudbeckia.—The rudbeckias, sometimes called coneflowers, are principally perennials, but there is one annual[34] that grows about 2 feet high and bears handsome yellow flowers with a brown center. (Fig. 30.) Not only is the disk brown, but the bases of the ray flowers as well. The seed may be sown in the open ground as soon as freezing weather is past, or for earlier bloom it may be sown under glass. The plants respond to plenty of manure, and they like warm, sunny situations, although they will grow readily almost anywhere.

The hardy perennial rudbeckias[35] may be treated as annuals. The flowers are quite showy and usually have yellow rays, though some are crimson and others more or less covered with brown toward the base. The rudbeckias are very easy of cultivation, thriving in almost any soil and climate. Most of them prefer a moist soil but will thrive in the garden under ordinary cultivation.

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[33] *Celosia cristata* L.

[34] *Rudbeckia bicolor* Nutt.

[35] *Rudbeckia hirta* L., *R. triloba* L.

The black-eyed-susan (*Rudbeckia hirta*), or "niggerhead" as it is sometimes called, will thrive in the hottest and driest situations. *R. triloba*, a biennial, perpetuates itself through self-sown seeds. It may be used effectively as a border to a large bed of delphiniums or as a screen, as it forms a dense bush between 3 and 4 feet high.

The rudbeckias are propagated from seeds or cuttings or by division. They are easily handled. When grown from seeds they may be sown in the open ground as soon as it is dry enough to work after freezing weather, or earlier with heat. The goldenglow,[36] one of the most satisfactory hardy perennials, is well adapted for planting in a shrubbery or herbaceous border. It is propagated by division of the roots. It grows to a height ranging from 3 to 6 feet and may be used as a screen when lower growing plants are placed in the foreground.

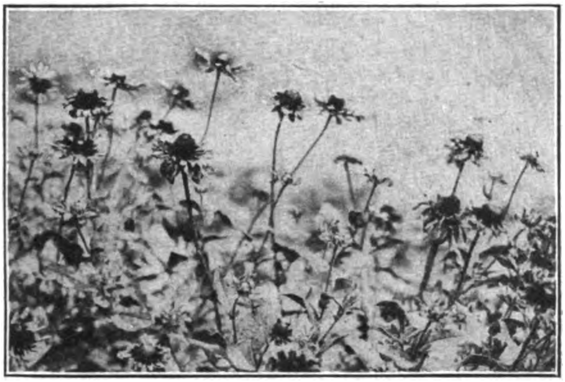

FIGURE 30.—Rudbeckia

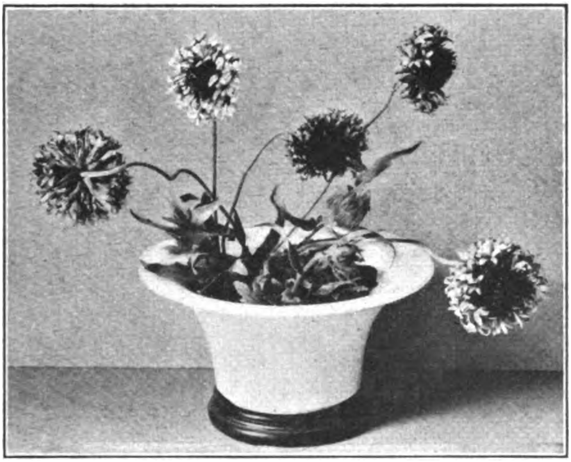

FIGURE 31.—Gaillardia

Gaillardia.—In the gaillardias,[37] or blanket flowers, are found both annual and perennial plants of easiest culture, offering a wide selection of varieties and a profusion of bloom over a long period. The blooming period begins early and continues late in the fall. These are plants well adapted to mixed borders (fig. 31) and are very satisfactory as cut flowers. The stems are of good length, carrying the orange and crimson flowers well, while the cut flowers keep fresh for a long time when placed in water.

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[36] A double-flowered form of *Rudbeckia laciniata* L. [37] *Gaillardia pulchella picta* Gray.

The annual gaillardias are all propagated readily from seeds sown where they are to grow soon after freezing weather is past, although they can be started under glass and be transplanted to their permanent location as soon as killing frosts have passed. In either case the blooming plants should not stand closer together than 10 to 12 inches. They grow and bloom best when fully exposed to sun and air and when planted on a fertile but light and well drained soil.

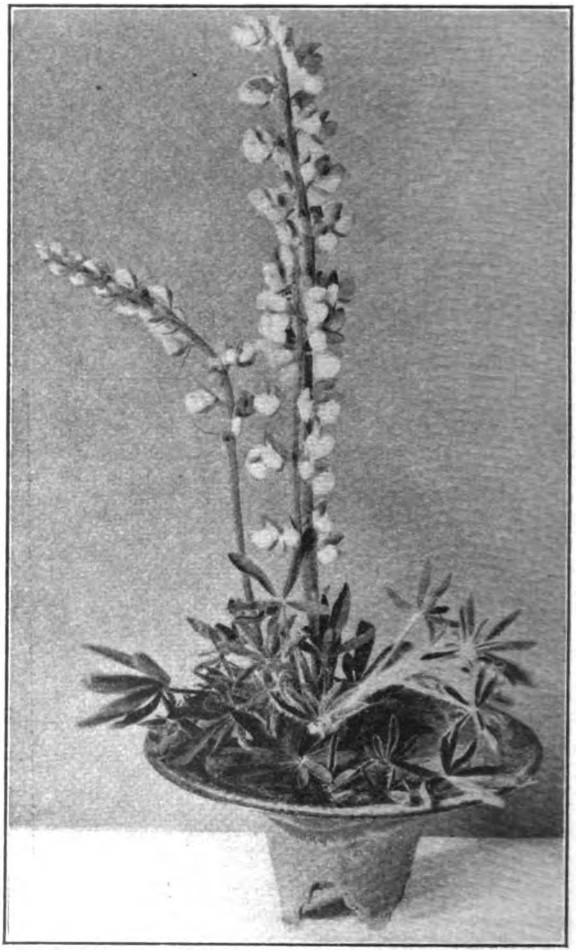

FIGURE 32.—Lupine

Lupines.—Lupines[38] (fig. 32) are blue-flowered hardy annuals of easy culture that succeed in partial shade. They grow about 2 feet high and are useful in mixed borders, in beds, and for cutting. They should be sown in the open ground as soon as the soil is fit to work, or earlier under glass.

Aztec marigold.—The Aztec marigold[39] formerly called African marigold, is the tallest of three distinct types of garden marigolds, each with numerous horticultural varieties. Each type is derived from a different species. They are popularly spoken of as African marigold, French marigold, and dwarf marigold or tagetes, but their common names give no clue to their nativity. The first is not only the tallest but is more spreading in growth and is well adapted to herbaceous or shrubbery borders. It frequently grows 2 or more feet in height, and for this reason it is better suited for planting in mixed borders or along belts of trees and shrubs than in beds or massed in small areas. This is the common marigold of the garden in America. (Fig. 33.) The leaves and flowers are strong scented, while the range of color is from sulphur yellow to orange, the darker shades being more commonly met with than the lighter ones.

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[38] *Lupinus*, several species.

[39] *Tagetes erecta* L.

These plants may be started under glass or in the open ground as soon as freezing weather is past. They are of easiest culture.

Balloonflower.—The platycodons, balloonflowers, or Japanese or Chinese bellflowers,[40] are blue and white flowered hardy perennials, which succeed fairly well as annuals. The seed may be sown as soon as freezing weather is past, and the plants will begin to bloom in about four months. They will thrive in any good garden soil, but are not as readily grown as many of the true annuals.

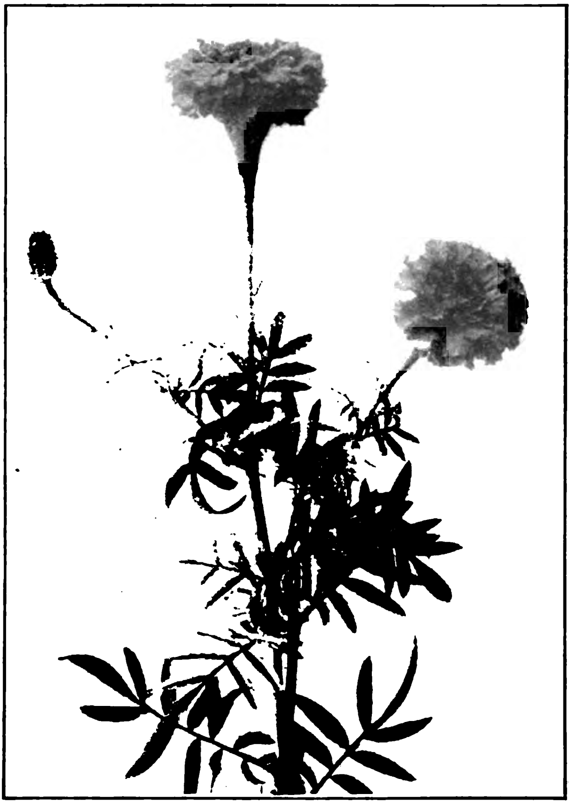

FIGURE 33.—Aztec marigold

Salpiglossis.—The salpiglossis[41] or painted tongue is an unusually dainty and attractive funnel-shaped flower ranging from white to purple and crimson, more or less veined with gold, and borne on slender upright stems that give the whole plant an air of distinction. (Fig. 34.) The seed should be sown early under glass or in the open ground as soon as danger of frost is past.

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[40] *Platycodon grandiflorum* A. DC. and *P. grandiflorum japonicum* Stubenrauch.
[41] *Salpiglossis sinuata* Ruiz and Pav.

It is not suited to bedding, but is beautiful in the border or for cutting. It is a little more difficult to grow than some of the other annuals.

Snapdragon.—The snapdragon[42] is a valuable border plant. It is a perennial but flowers the first year from seed sown in the spring. The bright color and peculiar form of the flowers (fig. 35) always attract attention. The newer sorts offer an enlarged variety of colors and of markings ranging from white to yellow and scarlet. The spikes are useful for cutting, keeping fresh a long time. From seed sown in the open ground when danger of frost is past blooms will be obtained in about 10 weeks. For early flowers the seed should be sown under glass and transplanted into beds of warm, dry soil moderately enriched. If protected by a coldframe or even a mulch of leaves in the North, the plants will winter well and bloom early the following year. The snapdragon, like most perennials and biennials that bloom the first year and of which a particular display is desired, should be treated as an annual and sown every year. The plant is of easy culture and blooms freely and continuously until frost.

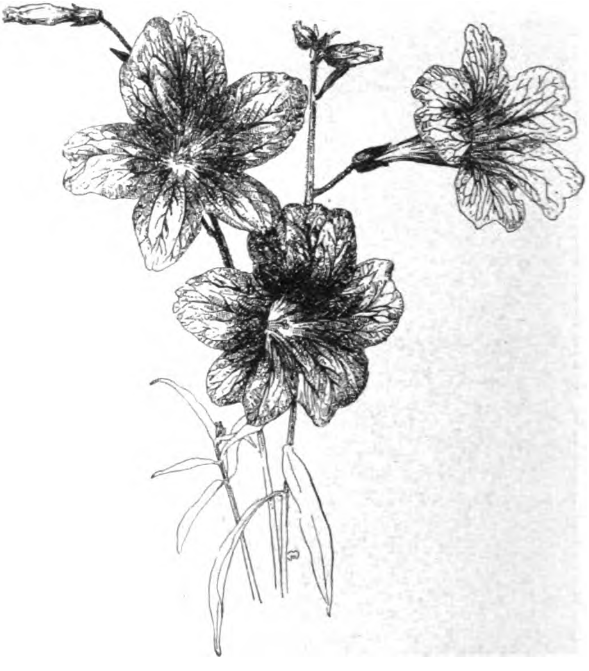

FIGURE 34.—Salpiglossis

Balsam.—The garden balsam[43] is a native of India. It likes hot sun, rich soil, and plenty of water. The young plants are quick, sure growers, and seeds sown in the open ground about the time of the last frost soon form handsome bushes thickly massed with large roselike white, pink, or rose-colored flowers. (Fig. 36.) Transplanting two or three times has a tendency to dwarf the plants into better shape and to make the flowers more double. Balsams are not often given room to perfect their development; they will easily cover from 12 to 18 inches of space each way. For the finest flowers choice seed is more than usually essential, as cultivation and selection have wrought wonders with this plant. The one objection to the balsam is its habit of producing its flowers on the under side of the leaves or inside the plant as it were. While the individual flowers are beautiful, the obscure manner in which they are borne detracts considerably from their ornamental value. When used at the margin of groups or to crown a terrace bank they are shown to best advantage.

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[42] *Antirrhinum majus* L.

[43] *Impatiens balsamina* L.

For early blooms balsam seeds should be sown in a gentle hotbed or in a dwelling house about eight weeks before the last frost. As soon as the first true leaves have developed, the young plants should be transplanted to thumb pots or to boxes, where they will stand about 2 inches apart each way. An abundance of light and water is at all times necessary for success with these plants. Care should be exercised to prevent them from becoming drawn, as stocky, symmetrical plants produce the best flowers. They should be transplanted to the open when the weather has become warm, as they will not stand frost.

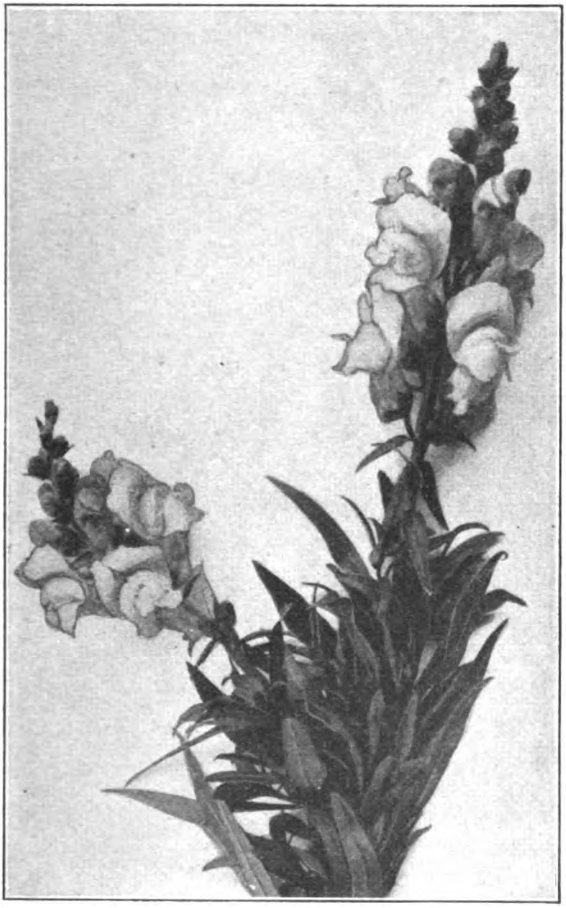

FIGURE 35.—Snapdragon

Poppy.—In the spring, even before tulips are fairly gone, old gardens begin to be gay with poppies.[44] No other plants possess so bold and brilliant a flower, coupled with the same grace of stem, airiness of poise, and delicacy of tissue. For beds and borders, with a background of green, there is nothing that will produce a more striking contrast than their white, pink, or scarlet flowers. Some sorts are admirable for naturalizing in open wooded grounds; others, like the beautiful Shirley poppy,[45] may be used for cutting, though these last only a few hours.

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[44] *Papaver,* several species.

[45] *Papaver rhoeas* L.

A sandy loam suits poppies best. As their strong taproots are difficult to transplant, it is well to sow the seed where the plants are to bloom. Sowing seed just before winter and at intervals in the spring, the first sowing being while the ground still freezes at night, will provide a long succession of flowers. The seeds should be sown thinly and covered very lightly, as they are very small. As soon as the young seedlings are well established the plants should be thinned to stand about a foot apart. The plants that bloom most profusely are those grown from fall or early spring sowings while the earth is cool and moist. They may be sown as early as the soil can be worked. They are well adapted to the use of the beginner.

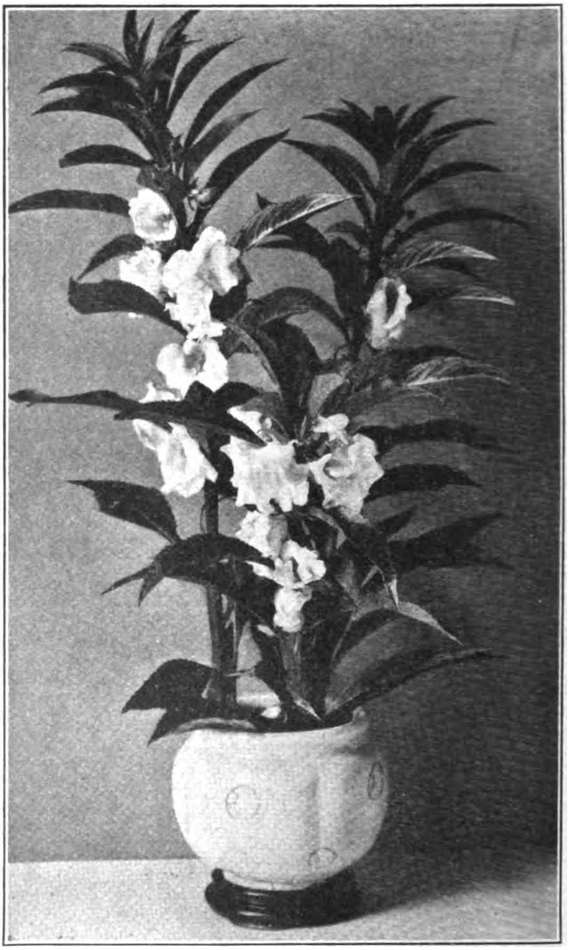

FIGURE 36.—Garden balsam

Snow-on-the-mountain.—Snow-on-the-mountain[46] is a strong-growing hardy annual foliage plant whose attraction lies in the white borders to the bright green leaves. (Fig. 37.) It is very showy in mass, but needs a facing of other plants, as it is apt to form a broad head with few branches near the ground. Its flowers are inconspicuous.

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[46] *Euphorbia marginata* Pursh.

The seeds should be sown in the open ground when freezing weather is past, or earlier under glass. The plant is easily handled and will grow in almost any soil, but it makes the greatest growth where there is plenty of fertility and is the most showy on poor ground. It frequently reseeds itself.

PLANTS GROWING ABOUT 18 INCHES HIGH

Plants that grow about 18 inches high are the globe-amaranth, four-o'clock, godetia, Jobs-tears, mignonette, rose everlasting, and stock.

Four-o'clock.—The four-o'clock,[47] sometimes called the "marvel-of-Peru," is normally a perennial in its native region, the warmer parts of America, but under garden culture gives satisfactory results when treated as an annual. (Fig. 38.) The seed may be sown under glass and the plants set out after danger from frost is past. The four-o'clock is often used as a low screen with good results. The colored part of the flower is white, various shades of red and yellow, and striped.

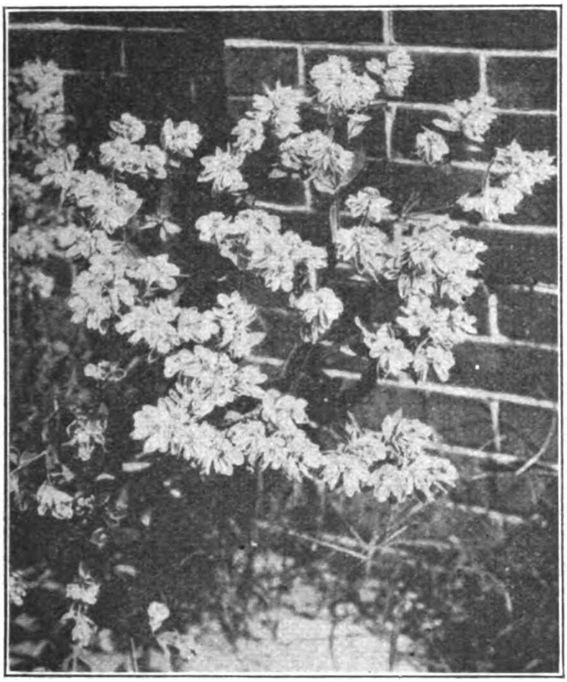

FIGURE 37.—Snow-on-the-mountain

The plant is a quick-growing, erect, bushy herb that is easily handled and attains a height of 18 inches. Its blooming period is during the late summer and fall. Because of the habit of opening its flowers only late in the afternoon and on cloudy days the popular name four-o'clock has been given to it. While this plant is a tender annual in the northern part of the United States, it often reproduces itself from self-sown seed, and even as far north as New York City it frequently manifests its perennial habit of developing tuberous roots sufficiently large to be lifted and stored like those of the canna.

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[47] *Mirabilis jalapa* L.

Godetia.—The godetia[48] is a close relative of the evening primrose. The native California godetias are spoken of as "farewell-to-spring." It is a choice free-blooming annual with widely open flowers (fig. 39) of satiny texture and delicate rose, light purple, and white. They are suited for solid beds, border lines, for pots, and to grow in shrubbery borders in shaded places where few other flowers will flourish. The seed should be sown in the open or in a coldframe in spring. If the latter, the seedlings should be transplanted to stand about a foot apart in rather thin or sandy soil. These plants are successfully treated as biennials by sowing the seed in July and in the North transplanting the young plants to a coldframe, to be placed in the open the following May. The blooming season is from early spring until frost, and the average height of the plants is 1½ feet.

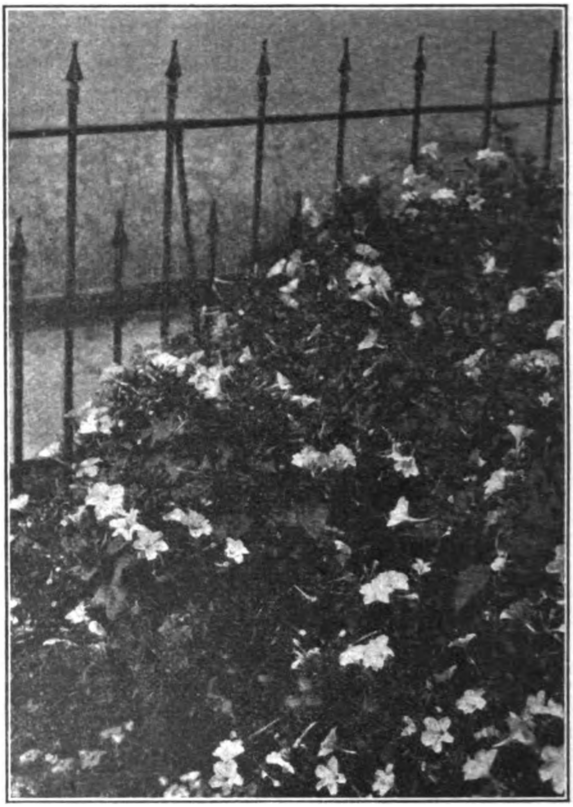

FIGURE 38.—Four-o'clock

Globe-amaranth.—The globe-amaranth,[49] sometimes called bachelor button, is an attractive and useful bedding plant growing to a height of 12 to 24 inches. The flowers are predominently red and somewhat resemble clover heads. (Fig. 40.) They are often cut as everlastings. The seeds should be sown in the open ground soon after freezing weather is past, or they may be started under glass if desired.

Jobs-tears.—Jobs-tears[50] is a grasslike annual, suggesting diminutive corn in its habit of growth. (Fig. 41.) Its chief attraction is the beautiful seeds that are often used as beads. The plant itself is graceful, though not attaining a height of over 18 inches in the North. In the South it grows much larger, even being suggested as a forage crop. About the date of the last frost, seed should be sown where the plants are to grow. Two or three plants may grow together in clumps 8 to 10 inches apart.

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[48] *Godetia amoena* Lilja. [49] *Gomphrena globosa* L. [50] *Coix lacryma-jobi* L.

Mignonette.—Every indoor or outdoor garden must have mignonette[51] in plentiful supply. The seed can be sown at any time, and if successive plantings are made its fragrant modest-colored flowers (fig. 42) may be gathered outdoors until November. It is of easy culture. For early blooms in the open, seed should be sown in pots or boxes under glass eight or ten weeks before danger of frost is over and the seedlings thinned or potted off to make stocky plants for bedding out as soon as severe frosts are past. To insure a succession of bloom throughout the season, sow a row or two at a time in the open about two or three weeks before time for the last frost, repeating regularly at intervals of about three weeks until August. The July sowing will make good winter-flowering plants. The average height of mignonettes is from 9 to 18 inches.

Rose everlasting.—Rose everlasting,[52] listed in florists' catalogues as acroclinium, is attractive in a mixed border and can also be cut as an everlasting. Its flowers are white or rosy pink, and the plant grows to a height of about 15 inches. It should be sown in the open ground after the heaviest frosts are past.

Stock.—Stocks[53] are easily grown, vigorous, have good habits (fig. 43), fragrant flowers in various colors, a long season of bloom, and are adapted to a wide range of cultural conditions. Stocks are suitable for bedding, edgings, pot culture, house or conservatory use, and for cutting. For bouquets and floral work the double white sorts are especially useful, although there are also rose, purple, crimson, and other colors. To obtain early flowers, seeds should be sown under glass before freezing weather is gone and the young seedlings transplanted when an inch high into other pots or boxes or into the fine soil of a spent hotbed. Advantage should be taken of showery weather, as soon as danger from frost is past, to transfer the plants to garden beds of deep rich soil, setting them about a foot apart each way. As with other plants, frequent transplantings during the early stages of growth tend to give them a more dwarf and

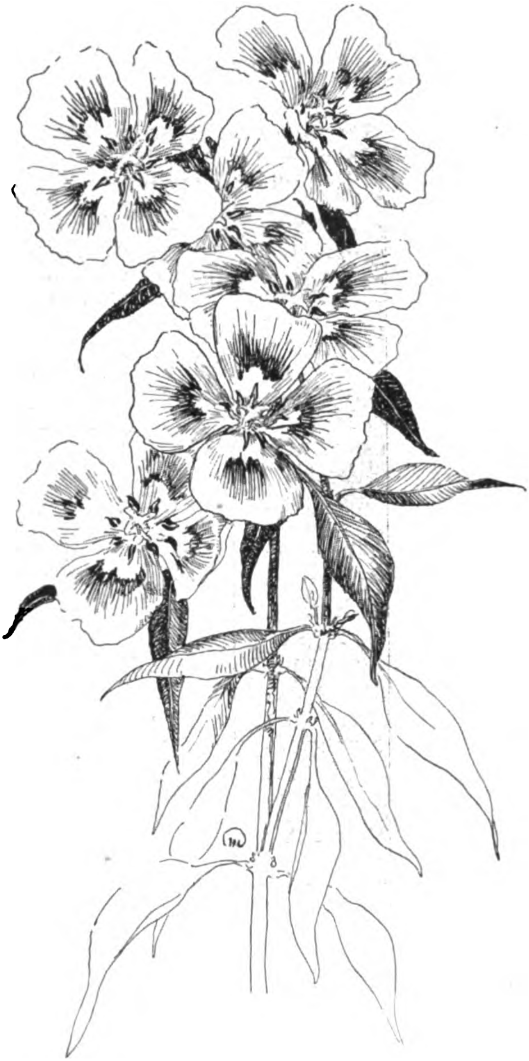

FIGURE 39.—Godetia

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[51] *Reseda odorata* L.

[52] *Helipterum roseum* Benth. and other species.

[53] *Matthiola incana annua* Voss.

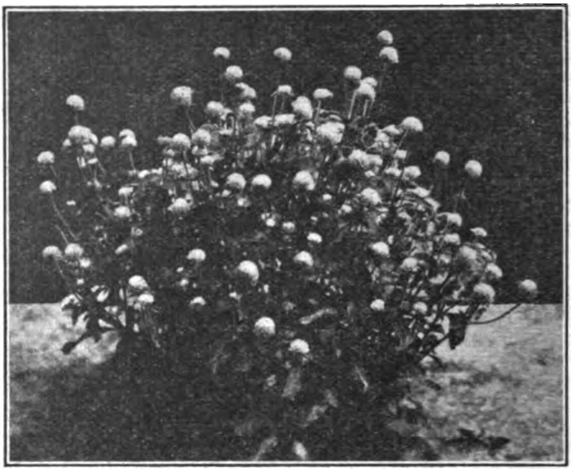

FIGURE 40.—Globe-amaranth

compact habit. For late flowers seed sowings may be made in the open ground a little before the last frosts may be expected. If plants that began to bloom late are carefully lifted and potted in the fall they will flower freely during the winter in a house or room that is tolerably cool and moist. The blossoms are very lasting. The average height of the stocks is from 12 to 18 inches.

PLANTS GROWING ABOUT 12 INCHES HIGH

Plants that are 12 inches high and of upright growth are the calendula, some dwarf varieties of calliopsis, candytuft, Cape-marigold, French marigold, annual (or Drummond) phlox, pink, Iceland poppy, and nemophila, while the California-poppy and petunia are spreading and will grow much farther than 12 inches, though they will not get higher than this unless supported in some way. Petunias can be trained on a support to a height of 3 feet or more, but the California-poppy can not be handled in this way because of its tender stems that do best resting on the ground.

Miniature sunflowers about 1 foot in height may also be obtained.

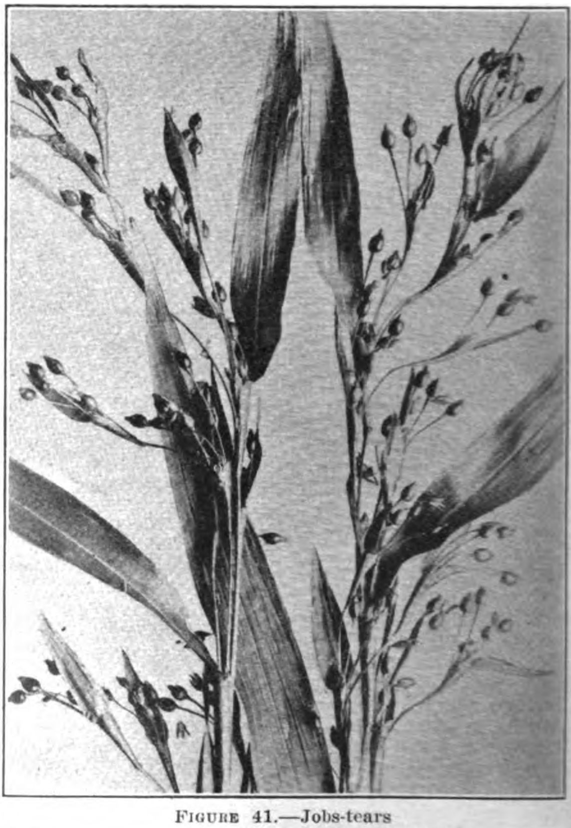

FIGURE 41.—Jobs-tears

Calendula.—The calendula,[54] or pot marigold, is a hardy annual about 1 foot high. A moderately rich light soil is most congenial to these plants, but they are readily grown almost anywhere. They should be placed about 8 or 10 inches apart if planted in masses (fig. 44) or in borders. The seed may be sown in the open ground quite early in the spring, and the plants will be in bloom early in summer and continue to bloom until late in the fall. The coloring of the flowers ranges through all shades of yellow, from ivory to deep orange. The plants bloom freely and earlier than the marigold and are useful in beds, borders, or backgrounds. The dried flowers are sometimes used for flavoring soups and stews. There are both single and double forms of the pot marigold. One of the most satisfactory methods of propagating this plant is from seeds sown about six weeks before danger of frost is past, in spent hotbeds or in coldframes. About or a little after the date of the last frost it will be safe to transfer the young plants to their permanent summer quarters.

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[54] *Calendula officinalis* L.

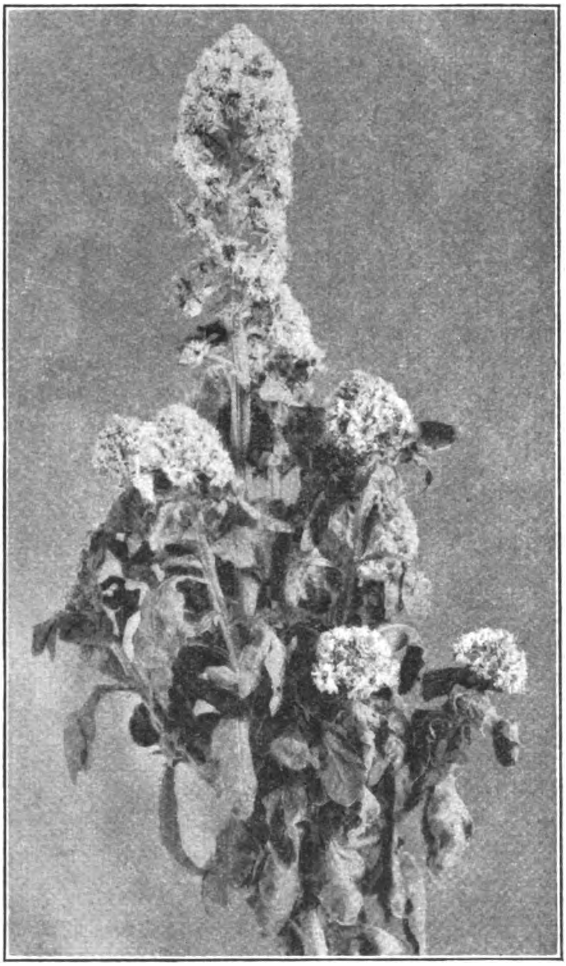

FIGURE 42.—Mignonette

Candytuft.—Candytuft[55] is among the best of the white flowers for edging beds (fig. 45); for planting in belts or beds, for massing, for rockeries, and for cutting. Several of the varieties are fragrant; all are profuse bloomers and are easily grown. There are also crimson, carmine, and lavender varieties. Soon after freezing weather is past the seed should be sown outdoors where the plants are to bloom. They should be well thinned when they have grown about 1 inch high. A second planting should be made a month later. and a third late in July for fall flowers. September sowing will give winter-blooming plants. The soil for best results should be rich and the plants given an abundance of water. They branch freely, and if some of the buds are removed the flowers remaining will be larger.

Cape-marigold.—The Cape-marigold,[56] also called African golden daisy (fig. 46), has an attractive orange to deep-yellow showy flower and grows 1 foot or more high and as broad. It is especially adapted to dry sunny locations. Seed should be sown outdoors after freezing weather is well over, or it can be sown earlier under glass and be transplanted to flats or pots and then set in the open ground after danger from frost is past.

French marigold.—The French marigold[57] (fig. 47) is more compact and regular in growth than the African marigold and consequently is more valuable as a bedding or low border plant. The habit of growth is erect and compact, with good foliage. The bright yellow and orange flowers are well formed and occur from June until frost. While these plants can be grown easily and are successfully brought into bloom from seeds sown in the open after danger of frost is past, they do not give as early bloom or the profusion of flowers that will be borne by plants that are started in a house and shifted for a time into pots, which confine the roots and check the plant, so that when set in the open ground the increased food supply will have a tendency to induce the development of flowers rather than wood, a tendency which will be likely to be maintained throughout the season. When transferred to the open the plants should be set at least 1 foot apart each way. The same distance should also be given the plants grown from seed sown in the open.

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[55] *Iberis umbellata* L., *I., amara* L.

[56] *Dimorphotheca aurantiaca* DC.

[57] *Tagetes patula* L.

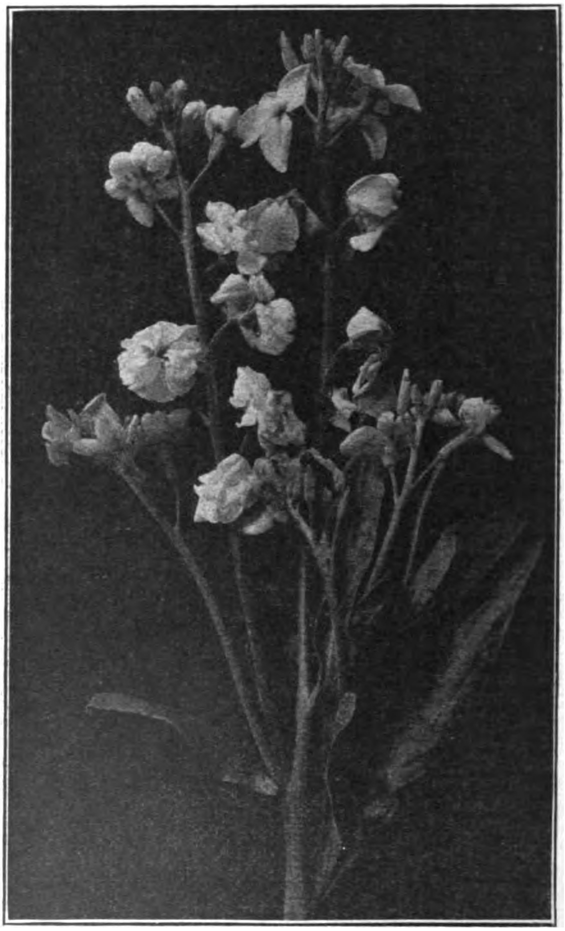

FIGURE 43.—Stock

There are both double and single forms of the French marigold. The named varieties are especially good, but very satisfactory results are obtained from mixed seeds.

Phlox.—Drummond phlox[58] is particularly useful and attractive when sown in masses or ribbon beds of contrasting colors. Few annual plants are more easily grown from seed, give a quicker return of bloom, or offer such a variety to choose from as do the phloxes. They are rich in reds, with a few varieties approaching buff and lilac. If given good soil, plenty of water, and full sunshine, they furnish throughout the season a supply of delicate flowers for cutting. (Fig. 48.) The phloxes are also useful as window-garden plants and may be used as an undergrowth for tall bare-stemmed plants.

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[58] *Phlox drummondii* Hook.

The first sowing of seed should be made as soon as frost is out of the ground in the spring; another a month later, either where the plants are to bloom or in a seed bed, as the phlox transplants readily. In transplanting set the taller kinds about a foot apart. If planted too thickly they suffer from mildew. The removal of flowers and seed pods makes the plants more bushy and compact and lengthens their blooming period. The average height of the plants is about a foot.

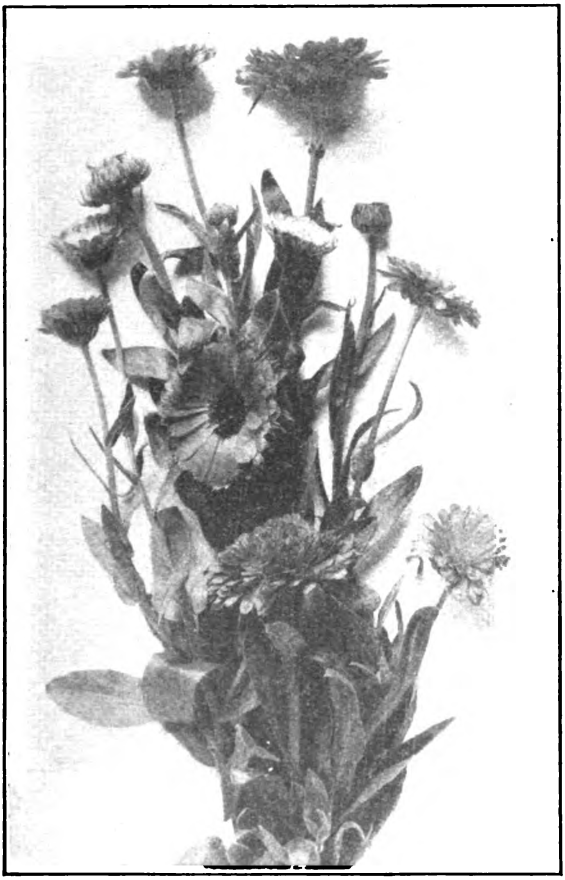

FIGURE 44.—Calendula

Pinks.—The large and varied genus of Dianthus contains some of our most beautiful and most profitable flowers. Most are hardy perennials that bloom freely the first season, the plants remaining green all winter and blossoming the next year if lightly protected by a mulch of straw, cut fodder, or leaves. Old plants flower earliest, but as young ones give the largest, finest flowers, sowings are made every year. Seed can be sown under glass or in an open sheltered bed as soon as the frost is out of the ground. The seedlings are easily transplanted and should stand 8 to 12 inches apart; dwarf ones, about 6 inches. If especially large brilliant flowers are desired, a bed of well-mixed turfy loam, leaf mold, and well-decayed manure should be prepared for them.

Good drainage should be provided as the plants are impatient of too much moisture and are more liable to winterkill in moist than in well-drained situations; in fact, the plant is hardy to severe cold, but succumbs when exposed to low temperatures in wet places. Pinks prefer a sunny location.

The flowers of all the plants of this group are most satisfactory for bouquets and table decorations because of the length of time they will keep in a fresh and attractive condition after being cut and placed in water. Their colors are chiefly white and shades of red.

The carnation pink,[59] which is the forcing carnation of the American florist, can be grown from seeds, but it usually will not bloom until five months or more from planting. The seeds should be sown very early in the season in hotbeds, the young plants being given frequent shifts to pots of increased size as they grow, until all danger of frost is past and the growing season is well on, when they may be transferred to the border where they are to bloom. If they are given a rich soil and an abundance of moisture the blooms will more than repay the extra trouble taken, but they are not to be counted on for very satisfactory results until the second season. Seedling plants are more variable in character than plants propagated from cuttings, and for that reason seedlings are not used by florists except in seeking for new varieties. On the continent of Europe this type of dianthus is more commonly used as a garden annual than in America.

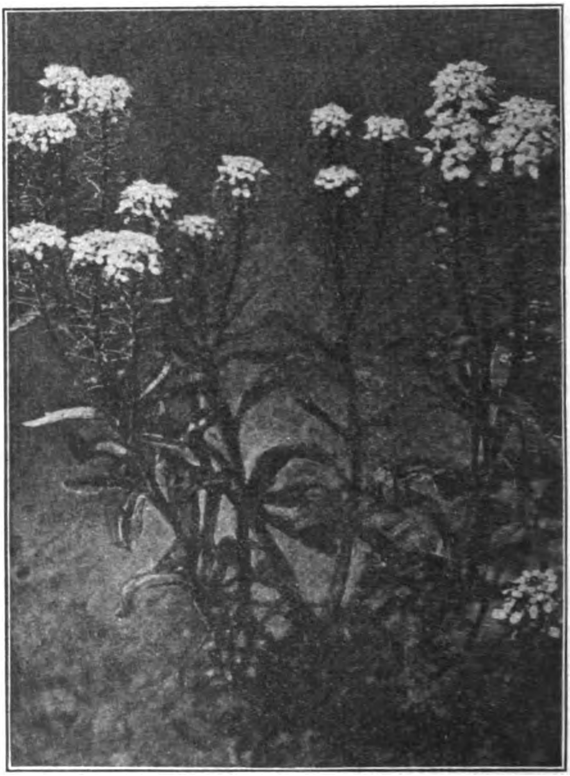

FIGURE 45.—Candytuft

The Chinese pink,[60] which is somewhat similar to the Japanese pink, is also a satisfactory plant handled in the same way. The varieties usually offered are double.

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[59] *Dianthus caryophyllus* L.

[60] *Dianthus chinensis* L.

The fringed pinks,[a] both single and double, are admired by many and are easily grown, satisfactory plants that do best in poor soil with plenty of sun.

The double-cluster pink, often called by seedsmen hybrid sweet-william,[a2] is one of the most satisfactory members of this group for annual planting. While seed can be sown in the open about the time frosts are over, the best results in the way of early bloom come from plants produced from seeds sown in a hotbed not later than six weeks before the last frosts, the young plants being pricked out into flats or preferably into thumb pots and later shifted to 3-inch pots before planting in the flowering border. The outside planting of hotbed-grown plants should be delayed until the season has advanced sufficiently to prevent the plants from suffering from a check by cold after being placed in the open. The pot-grown plants should be set at least 10 inches apart, and seedlings from seeds sown in the open had best be thinned to stand at least 8 inches apart.

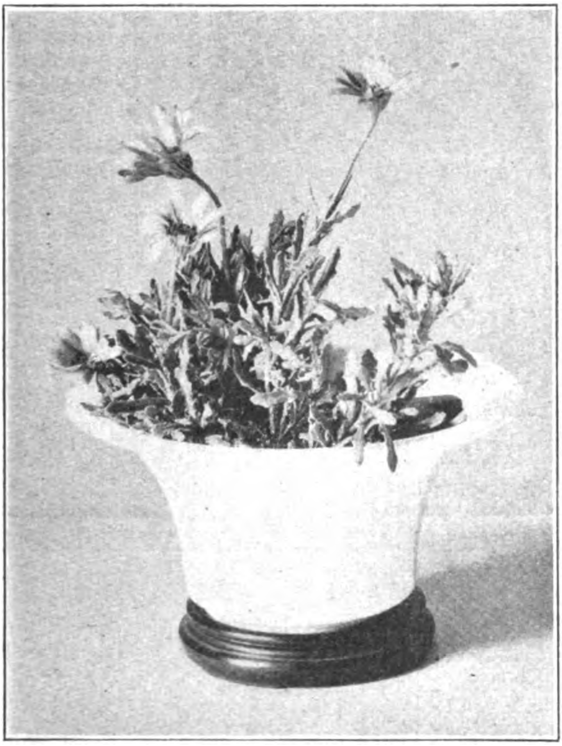

FIGURE 46.—Cape-marigold

One of the handsomest, most easily grown, and most satisfactory annual pinks is the Heddewig pink, often advertised as Japanese pink.[a3] (Fig. 49.) Seed sown early under glass or outdoors as soon as the ground is settled will give blooms by midsummer or before, and the plants will continue blooming until frost. Seed sown later will give some very late blooms and an abundance of fine flowers the next spring. There are both single and double varieties.

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[a] *Dianthus chinensis lacinatus* Regel.
[a2] A supposed hybrid between *Dianthus barbatus* and *D. chinensis*, often sold under the name *latifolius* Hort.
[a3] *Dianthus chinensis* laciniatus Regel.

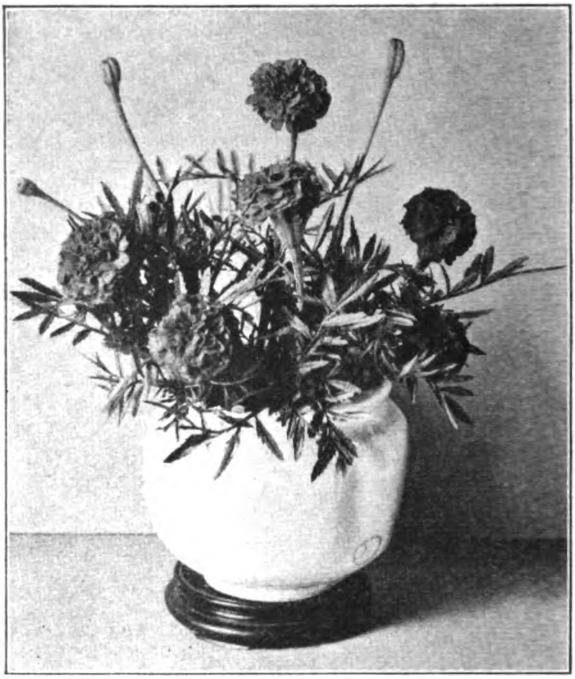

FIGURE 47.—French marigold

The Marguerite carnation[64] is well adapted to cultivation as an annual. Most of its flowers come double, and it has a pleasing habit of growth.

The grass-pink[65] is a hardy dianthus which, when treated as an annual, like the hybrid sweet-william, gives very satisfactory results. The delicately fringed, variously colored, pink and white fragrant flowers give the plant an odd yet attractive appearance.

The sweet-william[66] of old-fashioned gardens is a perennial, or at least a biennial, and needs to be sown in the summer for satisfactory results the following year.

Nemophila.—The representatives of the genus Nemophila[67] are dwarf, compact-growing, hardy annual herbs, about 12 inches in height, which produce an abundance of showy, bell-[illegible] flowers from early spring to late fall, for which reason they are estee[illegible] borders and for bedding purposes. All the species may be propagated fr[illegible] For summer and late fall blooms the seed may be sown in the open as soon as freezing weather is past, the plants being left without transplanting. The nemophilas love a cool, moist loam with partial shade and produce an abundance of showy blue, violet, and white margined and dotted flowers, which are very valuable for bedding and for cut flowers. These plants are especially adapted to the cooler parts of the country or for winter culture in the South. If the seeds are sown in the open about the middle of August and the seedlings transplanted in late autumn, very early flowers may be obtained.

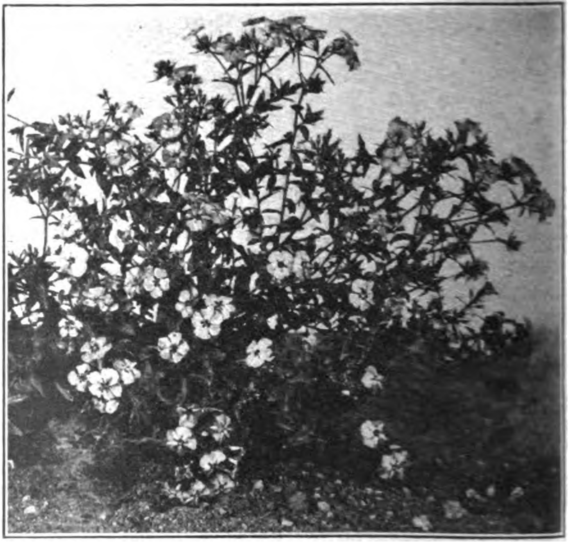

FIGURE 48.—Drummond phlox

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[64] A hybrid derived from *Dianthus chinensis* and some other species.
[65] *Dianthus plumarius* L.
[66] *Dianthus barbatus* L.
[67] *Nemophila menziesii* Hook. and Arn.

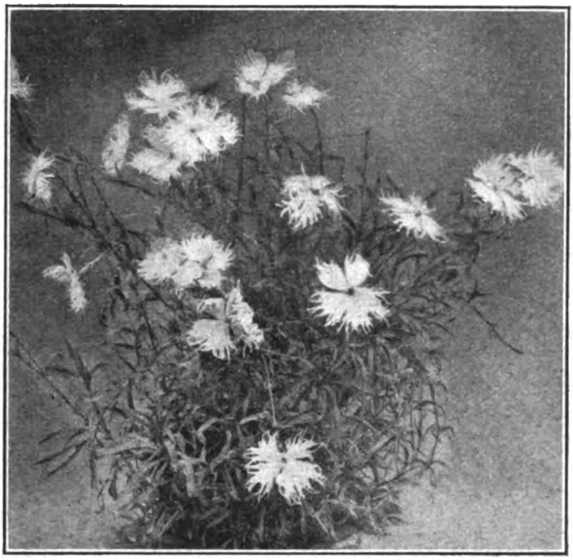

FIGURE 49.—Heddewig pink

Poppies.—The Iceland poppy[68] (fig. 50) is a dainty and attractive perennial that comes into bloom almost as soon as the true annual poppies. It grows about a foot high and bears its yellow, white, and deep-orange flowers on slender, graceful stems. If cut before opening, the blossoms keep quite satisfactorily. If the dead blossoms are kept picked off, the plants will continue to bloom the whole summer. Seeds are best sown where the plants are to grow, as early in the spring as the ground can be worked. The plants should be thinned to about a foot apart.

The California-poppy[69] is the State flower of California and an annual of striking character (fig. 51), as regards both the form and the color of its flowers, which are bright and rich in their tints of yellow and orange. The plants average about a foot in height, have attractive silvery foliage, and produce their large poppylike flowers quite lavishly from early spring until frost. They are most effective when grown in beds of considerable size, over which the seed may be thinly sown broadcast and then lightly raked in. These sowings may be made early in the spring or late in the fall for early germination and bloom the next spring. The California-poppy is also very useful as a pot plant and for cut flowers. It is easily grown.

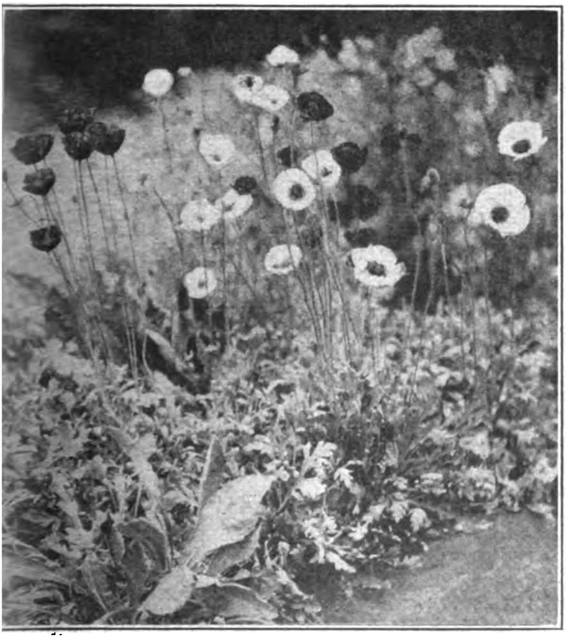

FIGURE 50.—Iceland poppy

Petunia.—Because of the ease and facility with which all of the single-flowered varieties of the petunia[70] can be grown from seed, this plant commands attention as a worthy candidate for the summer flower garden (fig. 52).

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[68] *Papaver nudicaule* L.
[69] *Eschscholtzia californica* Cham.
[70] *Petunia axillaris* B. S. P. (*P. violacea*).

The young plants grow rapidly and come into bloom early, and in addition to this they furnish a continuous wealth of blossoms until destroyed by frost. The large-flowered strains are very beautiful and of great variety. While the single sorts are common and inexpensive, the double giant-flowered varieties are expensive because they must be reproduced from seed which sets only after careful hand pollination of the flowers, which is in itself an expensive operation, or from cuttings, of which an individual plant can supply but a limited number. The colors range from white through rose to almost purple.

For the best results the seeds of all sorts should be sown in a gentle hotbed, a coldframe, or in fine soil in a box placed in a sunny window before or by the time freezing weather is over. When the soil has warmed sufficiently and the danger of frost has passed, the seedling plants should be transplanted to a rich garden loam and placed about a foot apart each way. The seed of the double varieties is less vigorous than that of the single sorts; therefore, to insure good germination, more attention to prevent extremes of temperature and of moisture is required. If the seeds are sown in boxes in a living room, a pane of glass may be kept over the top to maintain a close atmosphere and thus prevent the loss of moisture until the young plants are well out of the ground. In planting, the seeds should be scattered over the surface of the soil and brought in contact with it by firming. They should not, like most other seeds, be covered. In transplanting, the weaker, slower growing seedlings should not

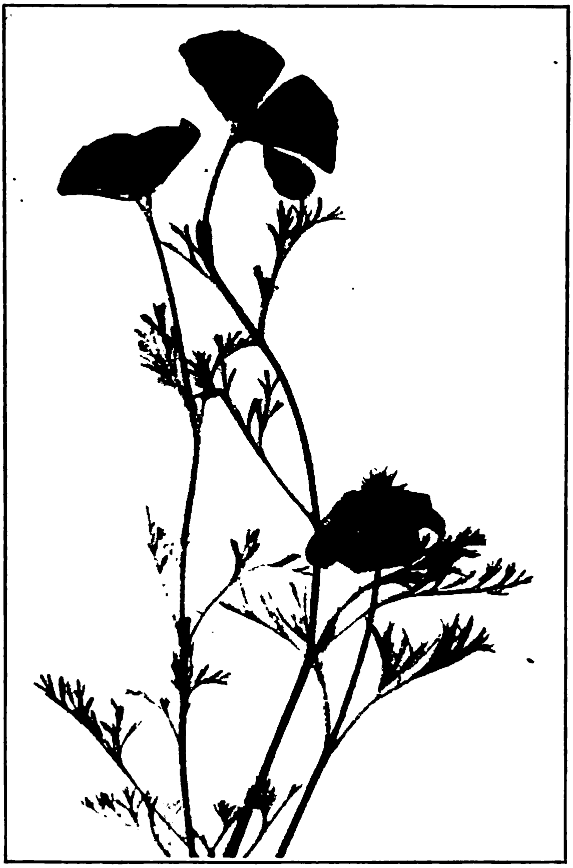

FIGURE 51.—California-poppy

be ignored, as they are likely to be the plants that will produce the finest blossoms.

Petunias are attractive in beds and masses, serve well for broad borders or bands, and thrive well in window boxes. They are not exacting as regards soil conditions, thriving well in almost any arable soil, and they endure drought well and bloom profusely.

PLANTS LESS THAN 12 INCHES HIGH

There are several desirable annuals for ornamental planting that do not grow to a height of a foot. Among these are the ageratum, belia, dwarf nasturtium, pansy, portulaca, sweet alyssum, tagetes, rget-me-not, and verbena, while the cockscomb has dwarf varieties ss than a foot in height.

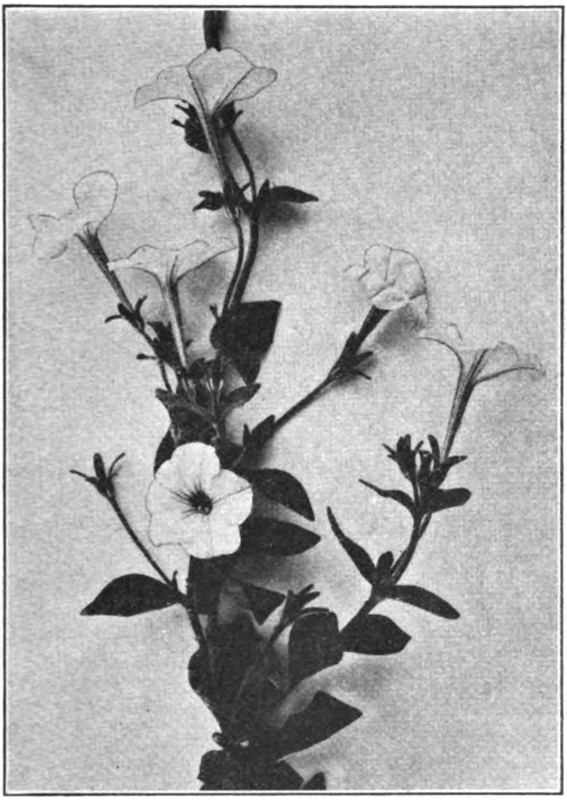

Figure 52.—Petunia

Ageratum.—For strengthening the garden's color forces in blue, no annual is good as the ageratum.[11] Though ordinarily used in bedding and borders in ntrast with such plants as geraniums, perillas, amaranthus, etc., the rose, hite, and blue ageratums are exceedingly attractive when mingled with sweet yssum, candytuft, and similar plants. They grow well upon almost all soils d through a wide range of climate; for that reason many combinations with em are possible. The plants are easily grown, neat, bushy, and erect, with continual profuse clustering of pretty brushlike flowers (fig. 53) throughout the season. The dwarf blue sorts make fine borders and are much used where contrasting color effects are desired. For early results the seed should be sown in coldframes or boxes in the house early in the season before freezing weather is past, but for summer and fall blooms the seeds may be sown in well-prepared beds in the open after the ground stops freezing. Seeds sown in August will produce good plants for winter flowering.

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[11] *Ageratum conyzoides* L., *A. houstonianum* Mill.

Lobelia.—The lobelias[72] are charming little plants that bloom very quickly from seed and continue gay with flowers all through the season. For beds, edgings, baskets, and pots there is nothing prettier; their clear white, and shades of blue, and their generous bloom make them welcome anywhere. (Fig. 54.) The seeds may be sown outdoors in early spring where the plants are to grow. As the plants appear they should be thinned moderately or transplanted several inches apart in rich open soil. Liquid manure applied while they are in bloom greatly improves the flowers. Many sorts are also good winter conservatory plants of trailing habit. There are perennial or tall varieties that are handsome, showy plants with red or with blue flowers, quite effective for background and grouping.

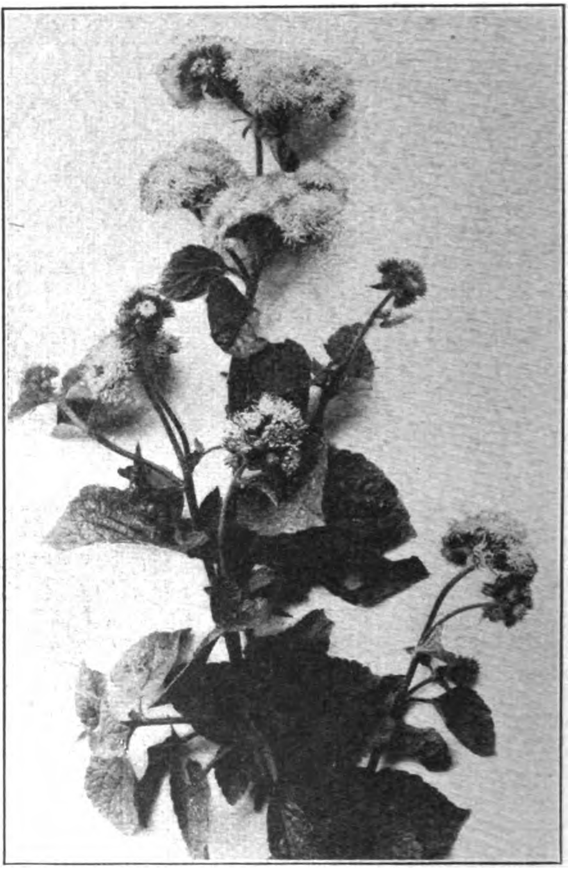

FIGURE 53.—Ageratum

Dwarf nasturtium.—A wide range of color has been developed in the dwarf or Tom Thumb nasturtium,[73] which for three or four months of the season makes a better display than almost any other plant. (Fig. 55.) No annual will produce such a profusion of flowers for so long a time with the same outlay of time and labor. The maximum of bloom is produced on thin soil, and the plant never flags through the hottest weather; in fact, too much rain or moisture greatly reduces the supply of flowers. In soil too rich the leaves predominate and the plants are apt to rot off in wet weather, especially if standing too close. The seeds should be planted an inch deep just after the last frost, and the seedlings should be thinned to 10 or 12 inches apart. The rows should be not less than a foot apart.

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[72] *Lobelia erinus* L.

[73] *Tropaeolum majus nanum* Hort.

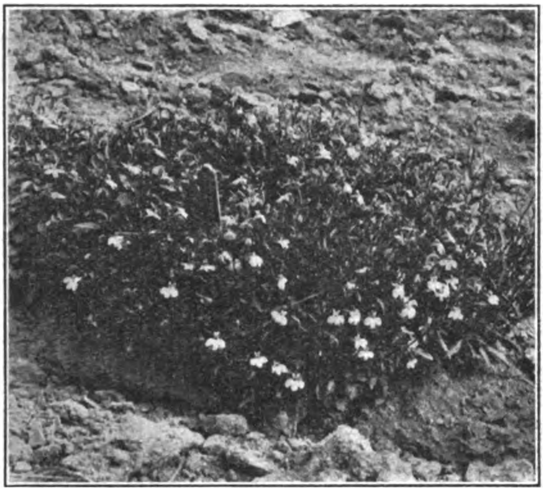

FIGURE 54.—Lobelia

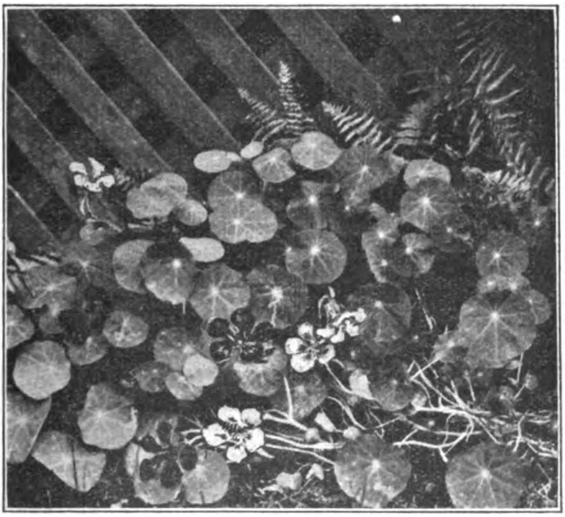

FIGURE 55.—Nasturtium

These plants have a neat, compact habit of growth and attractive foliage nd are not infested by insects. Blossoms appear in two months from the ate of seed sowing and continue throughout the whole season. A bed of dwarf asturtiums in full bloom is a sea of yellow and orange, mixed with browns, aroons, and lemon. It is said that a good bed, 6 by 20 feet in size, will yield bout 1,000 flowers each day. The average height is 9 inches.

Pansy.—The pansy,[74] sometimes called heartsease (fig. 56), is a favorite with almost everyone. The flowers are usually yellow or purple, more or less splotched, sometimes almost white or almost black. The pansy is a plant that demands more than ordinary attention, but none repays such attention more liberally. For very early outdoor bedding the seed is sown in the fall (September) in a coldframe or in rich moist garden beds, from which the plants can be transferred before severe winter weather begins. South of St. Louis and Cincinnati the transplanting can be to the beds where they are to bloom. North of these cities they should be transferred to a coldframe, setting them 2 or 3 inches apart each way. In the spring three-fourths of them can be lifted out for bedding and the rest left to bloom in the frame. For winter bloom in a frame, set the plants about twice as far apart and thin out half of them in the spring. Cover the blooming plants with sash, adding a covering of matting or straw in very cold weather. In mild weather remove the mats and tilt the sashes to admit light and fresh air and to prevent the plants from becoming drawn. In outdoor beds raised a few inches above the ground with a mulch of dry leaves and some brush to hold them in place, pansies will often winter well in the North and bloom until midsummer, when a relay of young, vigorous plants should be ready to replace them.

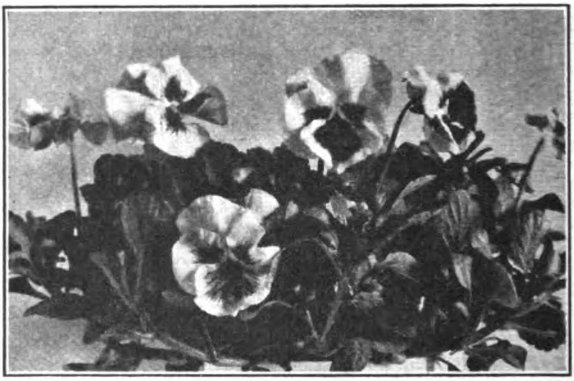

FIGURE 56.—Pansies

Spring sowings should be made early, so as to secure good flowers during the early rains. Seeds sown in a cool, moist place in June and July and well tended will give good flowering plants for fall. If they come into bloom in the heat of the summer, the flowers may be small at first; but as the weather becomes cooler they will increase in size and beauty. Through the summer heat the flowers are finer in a somewhat shaded place, but in almost any situation good pansy seed will produce fine flowers in spring and fall. Early fall sowings give the finest spring flowers.

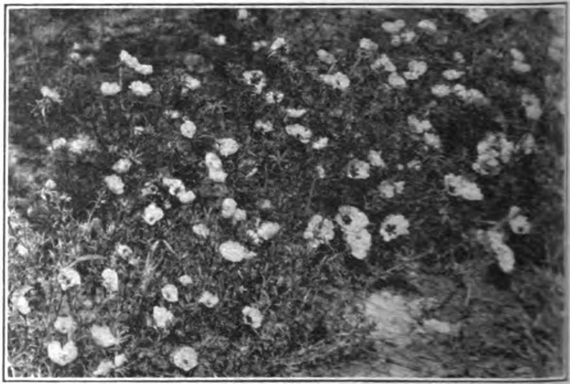

FIGURE 57.—Portulaca

In the South much better results may be expected with these plants in the winter than in the summer.

Portulaca.—The bright-flowered, thick-leaved portulaca,[75] sometimes called sun plant, is unrivaled for brilliancy among plants of low growth. It possesses the ability to flourish under extremely adverse conditions; even hot sun and light sandy soil with sparse water supply will not destroy it. It is satisfactory for beds, edgings (fig. 57), and rockwork, and for filling up irregular spaces or unexpected gaps in flower beds; as an undergrowth for taller plants it is also valuable. It carpets the ground with a mat of succulent foliage that in the forenoon is hidden by the gayest flowers, ranging through the reds and yellows. The plant is particularly useful in the Northwest. The seed does not germinate until hot weather and should be sown late. Beyond the sowing this plant requires little care. The endurance of the plant is shown by the fact that it can be transplanted while in full flower through the driest, hottest seasons. The average height is 6 inches.

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[74] *Viola tricolor* L.

[75] *Portulaca grandiflora* Hook.

In the southern half of the country portulaca will perpetuate itself by self-sown seeds. In some soils this is sufficient to cause the plant to assume a weedy character. It never becomes troublesome like its near relative, the weedy garden purslane or "pusley" (*Portulaca oleracea*).

Sweet alyssum.—Sweet alyssum[76] is a most easily grown, dainty little white flower, recommended to be used liberally for borders, edging, baskets, pots, rockwork, and for cutting. (Fig. 58.) For borders the seed should be sown thickly, so as to form masses. For winter bloom sow late in August and thin the seedlings to stand about 4 inches apart, but for spring bloom for borders the seeds should be sown in the open early in the spring, or even late in the preceding fall in some localities. Where the plant will not endure the winter, however, early spring planting under cover, either in a coldframe, a spent hotbed or in boxes in a dwelling, is most to be relied upon. It can also be increased from cuttings made from strong new side shoots, as well as by division of the roots. By cutting back after the first flowers fade others will be produced.

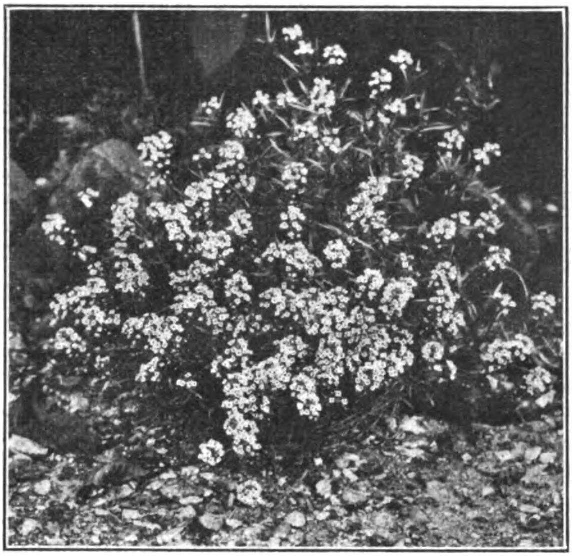
FIGURE 58.—Sweet alyssum

The Carpet of Snow variety is only about 4 inches high and is probably one of the most satisfactory, as its habit of growth is so compact that blooms that die during the season do not give it the ragged appearance sometimes seen in the larger varieties. It blooms continually from spring till fall. While sweet alyssum is white, there are perennial varieties that are yellow.

Dwarf marigold.—Dwarf marigold,[77] or, as it is frequently listed in catalogues, tagetes, is the very dwarf, compact single marigold with almost fernlike leaves. The plants are scarcely more than 8 inches tall and bear freely their bright yellow blossoms. They can be started in the open ground soon after freezing weather is past and are readily grown.

Verbena.—The verbena[78] is a low-growing annual with a creeping habit. The flowers are borne on terminal or lateral shoots which lift themselves from 5 to 7 inches off the ground, and when grown in mass the plants will form a mat that in full bloom will give the soil the appearance of having a carpet of flowers. Because of the ability of the plant to form a compact growth and produce a wealth of flowers over a long period, the verbena is frequently used as a bedding plant where carpet-bedding effects are desired. The contrasting colors in the varieties, which come true from seed, allow the securing of pleasing combinations which are effective where low-growing plants can be used. The colors include white, pink, scarlet, blue, and purple. The length of stem and the texture of the flower (fig. 59) are such that the verbena is of value for bouquets and table decorations. It can be used with good effect for beds, borders, mounds, and window boxes.

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[76] *Lobularia maritima* Desv. (*Alyssum maritimum*).
[77] *Tagetes signata pumila* Hort.
[78] *Verbena chamaedryfolia* Juss., *V. phlogiflora* Cham., *V. teucrioides* Gill. and Hook., *V. incisa* Hook.

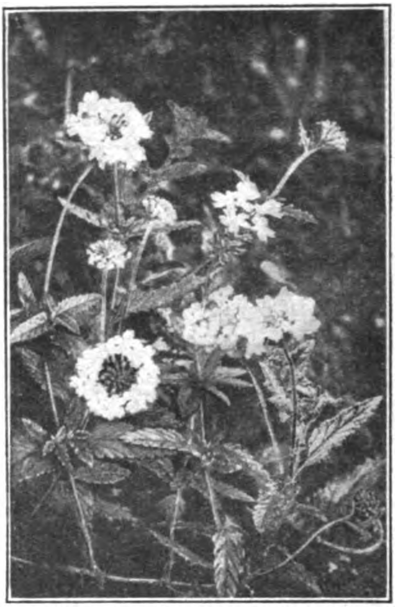

FIGURE 59.—Verbena

While the verbena grows readily from cuttings and from layers, seedling plants are more vigorous and as a rule produce better flowers. For the earliest bloom, sow the seeds at least a month before the ground stops freezing at night, starting them in a moderately warm living room or greenhouse. For general outdoor planting the seeds may be sown about five or six weeks before the last frost either in a living room, a hotbed, or a greenhouse. Soak the seeds a few hours in tepid water and sow in seed boxes filled with light rich soil; cover one-fourth of an inch deep, press down firmly, and water sparingly. When the seedlings are about an inch high transplant them into other boxes, placing the young plants 2 or 3 inches apart each way. If thumb pots are available, use these in place of boxes. When all danger of frost is past choose a bright, sunny situation in which to plant them. Make the soil rich and compact rather than light, but in all cases provide good drainage. Set the young plants 10 to 15 inches apart each way and give good cultivation until they cover the ground. With such treatment the verbena should give continuous bloom from early summer until killed by frost.

Forget-me-not.—The dainty little blue flowers commonly known as forget-me-nots[79] are hardy perennials that love cool, moist soils and, like pansies, bloom most freely in fall and early spring. There is also an annual species, with several varieties. They make a satisfactory close border (fig. 60), the beauty of which is heightened by abundant bloom. The forget-me-not is also satisfactory as a winter-blooming plant for growing in cool rooms or coldframes. Another feature characteristic of this plant is that, after once having been introduced into a garden, it perpetuates itself from year to year by self-seeding, like the poppy, portulaca, and several other desirable annuals. Sow the seeds in spring in a warm, sunny border, or in the South in late summer for winter bloom. Most varieties bloom freely the first season and profusely the second year if in a sufficiently cool, moist place. The average height of the plants is 6 inches. They do not succeed so well in dry, sunny situations.

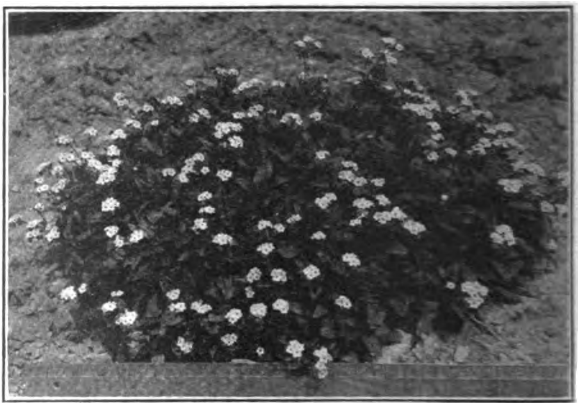

FIGURE 60.—Forget-me-not

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[79] *Myosotis scorpioides* L. (*M. palustris*).

PLANTS FOR SPECIAL SOILS OR CONDITIONS

Some plants that are desirable for special conditions are specified in the following lists:

For bright sunshine with plenty of fertility and moisture: Over 4 feet high, castor-bean, cosmos, sunflower, sorghum, feterita, milo, and Indian corn; over 3 feet, Josephs-coat, love-lies-bleeding, feather cockscomb, orange sunflower, princesfeather, spiderflower, and summer-cypress; 30 inches, cornflower, larkspur, scabiosa, scarlet sage, strawflower, and zinnia; 24 inches, balsam, calliopsis, China-aster, summer chrysanthemum, cockscomb, coneflower, four-o'clock, gaillardia, Aztec marigold, platycodon, poppy, salpiglossis, snapdragon, and snow-on-the-mountain; 18 inches, Jobs-tears, mignonette, and stock; 12 inches, calendula, California-poppy, calliopsis, candytuft, French marigold, petunia, Drummond phlox, pink, and Iceland poppy; under 12 inches, ageratum, cockscomb, lobelia, portulaca, sweet alyssum, and verbena.

Of easiest culture under ordinary garden conditions: Over 4 feet, sunflower; about 3 feet, Josephs-coat, love-lies-bleeding, heliopsis, and princesfeather; about 30 inches, cornflower, strawflower, and zinnia; about 24 inches, calliopsis, summer chrysanthemum, coneflower, gaillardia, marigold, poppy, and snow-on-the-mountain; about 18 inches, mignonette; about 12 inches, Cape-marigold, calendula, California-poppy, balsam, candytuft, petunia, Drummond phlox, pink, dwarf nasturtium, portulaca, and sweet alyssum.

On light fertile soil: Gaillardia, marigold, Drummond phlox, and portulaca.

On light soil, not too rich: Cockscomb and feather cockscomb.

On poor soil: Love-lies-bleeding, princesfeather, Josephs-coat, Cape-marigold, godetia, dwarf nasturtium, portulaca, grass-pink, sweet alyssum, garden balsam, and calliopsis.

On lands near the seacoast: Plants from the three foregoing lists, depending on the fertility of the soil, together with the castor-bean, sunflower, heliopsis, spiderflower, cornflower, strawflower, zinnia, calliopsis, snow-on-the-mountain, four-o'clock, stock, calendula, California-poppy, petunia, and sweet alyssum.

In partial shade: Basketflower, sweet-sultan, clarkia, platycodon, godetia, Drummond phlox, pansy, sweet alyssum, lupine, and forget-me-not.

Especially responding to rich soil: Castor-bean, scarlet sage, balsam, and China-aster.

To cut for everlastings: Rose everlasting, feathered cockscomb, globe-amaranth, and strawflower.

Not adapted to the South except for late and early spring: Salpiglossis, pansy, and forget-me-not.

Plants that can be started to advantage in hotbeds and coldframes for early flowering, whether they are to be used for bedding purposes or for cut flowers: Ageratum, China-aster, calliopsis, castor-bean, calendula, cosmos, cockscomb, chrysanthemum, godetia, lobelia, marigold, petunia, grass-pink, scarlet sage, spiderflower, and verbena.

Some plants that may be sown in beds in the open ground and later transplanted to their permanent locations are ageratum, calendula, calliopsis, China-aster, clarkia, cockscomb, dahlia, gaillardia, godetia, lobelia, mignonette, pansy, pink, snapdragon, spiderflower, stock, and zinnia. Most of these may be sown earlier in a hotbed or coldframe and thus be made to bloom earlier.

Some should be sown in the open ground where the plants are to grow.

Among those that should be sown early in that way are alyssum, California-poppy, candytuft, cornflower, forget-me-not, mignonette, nemophila, Drummond phlox, sunflower, poppy, and sweet alyssum.

Among those that should be sown late in this manner after the ground is warm are the castor-bean, sorghum, milo, feterita, Indian corn, garden balsam, portulaca, and four-o'clock.

For August and September sowing: Forget-me-not, pansy, cornflower, pink, and snapdragon.

Seeds that may be sown on well-prepared ground just before winter for early spring germination or on fall-prepared ground very early in the spring while the soil still freezes at night are the poppy, cornflower, cosmos, summer-cypress, larkspur, snapdragon, snow-on-the-mountain, and sweet alyssum.

Flowers that are white or with pure white varieties: 4 feet, cosmos; 3 feet, dahlia and sweet-sultan; 2½ feet, clarkia, cornflower, larkspur, and scabiosa;

2 feet, babysbreath, China-aster, summer chrysanthemum, lupine, balloonflower, snapdragon, garden balsam, and poppy; 1½ feet, godetia, four-o'clock, rose everlasting, and stock; 1 foot, candytuft, Iceland poppy, petunia, ageratum, lobelia, portulaca, sweet alyssum, and verbena.

Flowers having varieties mixed with white: 3 feet, dahlia; 2½ feet, salpiglossis; 1 foot, nemophila, pansy, petunia, and pink.

Flowers yellow or with yellow varieties: 4 feet, sunflower, feather cockscomb, and dahlia; 2½ feet, strawflower, sunflower, and zinnia; 2 feet, calliopsis, summer chrysanthemum, Aztec marigold, snapdragon, and four-o'clock; 1 foot, calendula, Cape-marigold, French marigold, Iceland poppy; California-poppy, dwarf marigold, and portulaca.

Flowers having varieties mixed with yellow: 4 feet, dahlia; 2 feet, calliopsis, rudbeckia, salpiglossis, and summer chrysanthemum; 1½ feet, four-o'clock; 1 foot, dwarf nasturtium and pansy.

Flowers of orange color or with orange varieties: 3 feet, heliopsis; 2½ feet, zinnia; 2 feet, Aztec marigold; 1 foot, calendula, Cape-marigold, French marigold, and California-poppy.

Flowers having varieties mixed with orange: 2 feet, gaillardia; 1 foot, dwarf nasturtium and French marigold.

Flowers lavender or with lavender varieties: 3 feet, basketflower and sweet-sultan; 2½ feet, larkspur; 2 feet, China-aster; 1½ feet, candytuft; 1 foot, Drummond phlox, nemophila, and pansy.

Flowers having varieties mixed with lavender: 2½ feet, salpiglossis; 1 foot, pansy.

Flowers blue or with blue varieties: 2½ feet, cornflower and larkspur; 2 feet, lupine and balloonflower; 1 foot, nemophila, ageratum, lobelia, verbena, and forget-me-not.

Flowers purple or with purple varieties: 3 feet, sweet-sultan; 2½ feet, clarkia and scabiosa; 2 feet, China-aster, 1½ feet, stock; 1 foot, verbena.

Flowers having varieties mixed with purple: 2½ feet, salpiglossis; 1 foot, pansy.

Flowers pink or with pink varieties: 4 feet, cosmos; 3 feet, dahlia; 2½ feet, larkspur and zinnia; 2 feet, China-aster, garden balsam, and poppy; 1½ feet, rose everlasting; 1 foot, Drummond phlox, pinks (including carnations), portulaca, and verbena.

Flowers having varieties mixed with pink: 3 feet, dahlia; 1 foot, pinks (including carnations).

Flowers salmon or with salmon varieties: 3 feet, dahlia; 2½ feet, clarkia; 2 feet, snapdragon and poppy; 1 foot, Drummond phlox.

Flowers having varieties mixed with salmon pink: 3 feet, dahlia; 1 foot, Drummond phlox.

Flowers scarlet or with scarlet varieties: 3 feet, dahlia; 2½ feet, scarlet sage and zinnia; 2 feet, snapdragon, poppy, and four-o'clock; 1 foot, Drummond phlox, pinks (including carnations), dwarf nasturtium, portulaca, and verbena.

Flowers having varieties mixed with scarlet: 3 feet, dahlia; 2 feet, snapdragon and poppy; 1 foot, Drummond phlox, pinks (including carnations), and dwarf nasturtium.

Flowers rose or crimson or with rose or crimson varieties: 4 feet, cosmos; 3 feet, princesfeather, feather cockscomb, sweet-sultan, and spiderflower; 2½ feet, clarkia, cornflower, scabiosa, and zinnia; 2 feet, garden balsam, China-aster, cockscomb, and lupine; 1½ feet, godetia, four-o'clock, globe-amaranth, stock, and candytuft; 1 foot, Drummond phlox, petunia, and portulaca.

Flowers having varieties mixed with rose or crimson: 1 foot, Drummond phlox and petunia.

Plants used for their foliage or chiefly for it, the foliage being green unless otherwise noted: 4 feet, castor-bean (bronze and green separate), sorghum, feterita, milo, broomcorn, and Indian corn; 3 feet, Josephs-coat (red, yellow, and green mixed), love-lies-bleeding (red), summer-cypress (pea green turning crimson in late summer); 2½ feet, annual poinsettia (scarlet leaves in late summer) and snow-on-the-mountain (white-edged leaves); 1½ feet, Jobs-tears; 1 foot, mignonette (a greenish flower grown for its sweet odor, but in its garden decorative value comparable to a plant grown for its foliage).

THE PRINCIPAL CHARACTERISTICS OF SOME ANNUAL FLOWERING PLANTS

The following list presents in easily accessible form the principal characteristics of some annual flowering plants.

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.; also the page in this bulletin where a description of each plant and directions for its culture will be found

Common name	Height of plant (feet)	Grown for flowers or foliage	Color of flowers or foliage	Preference for sun or shade	Hardiness to cold	Described on page
croclinium. See Rose everlasting.						
frican golden daisy. See Cape-marigold.						
frican marigold. See Marigold, Aztec.						
geratum	1	Flowers	Blue, white, rose.	Sun	Tender	51
lyssum, sweet	1	do	White	do	Very hardy	55
maranth, globe. See Globe-amaranth.	1½	do	Crimson or rose.	do	Hardy	40
maranthus caudatus. See Love-lies-bleeding.						
maranthus cruentus. See Princesfeather.						
maranthus tricolor. See Josephs-coat.						
ntirrhinum. See Snapdragon.						
ster, China. See China-aster	2	do	Purple, rose, white.	do	Half hardy	28
ztec marigold. See Marigold, Aztec.						
abysbreath	2	do	White	do	Hardy	27
achelor button. See Cornflower.						
alloonflower	2	do	Blue, white	Sun, partial shade.	do	35
alsam	2	do	Rose, pink, white.	Sun	Tender	36
asketflower	3	do	Rose, lavender	Sun, slight shade.	Hardy	18
ean, castor. See Castor-bean.						
ellflower, Chinese. See Balloonflower.						
ellflower, Japanese. See Balloonflower.						
elvedere	3	Foliage	Pea green	Sun	Very hardy	20
lack-eyed-susan. See Rudbeckia.						
lanketflower. See Gaillardia.						
luebottle. See Cornflower.						
luet. See Cornflower.						
roomcorn	4+	do	Green	do	Tender	17
alendula	1	Flowers	Yellow, orange	do	Half hardy	42
alifornia-poppy	1	do	do	do	Very hardy	49
alliopsis	2	do	Yellow, brown	do	Tender	27
andytuft	1	do	Crimson, lavender, white.	do	Hardy	43
ape-marigold	1	do	Orange, yellow	do	do	43
arnation, Marguerite. See Pink.						
arpet of Snow alyssum. See Alyssum, sweet.						
astor-bean	4	Foliage	Green, bronze.	Full sun	Tender	15
astor-oil plant. See Castor-bean.						
elosia plumosa. See Cockscomb, feather.						
entaurea americana. See Basketflower.						
entaurea cyanus. See Cornflower.						
entaurea imperialis. See Sweet-sultan.						
hina-aster	2	Flowers	Purple, rose, white.	Sun	Half hardy	28
hinese bellflower. See Balloonflower.						
hinese pink. See Pink.						

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.—Continued

Common name	Height of plant (feet)	Grown for flowers or foliage	Color of flowers or foliage	Preference for sun or shade	Hardiness to cold	Described on page
Chrysanthemum, summer	2	Flowers	Yellow, white	Sun	Tender	19
Clarkia	2½	do	Salmon, white	Sun, partial shade.	Hardy	22
Cleome spinosa. See Spider-flower.						
Cockscomb	2	do	Crimson	Sun	Tender	22
Cockscomb, feather	3	do	Crimson, yellow.	do	do	18
Cockscomb, plumed. See Cockscomb, feather.						
Coneflower. See Rudbeckia.						
Coreopsis. See Calliopsis.						
Corn, broom. See Broomcorn.						
Corn, Indian	4+	Foliage	Green	do	do	17
Cornflower	2½	Flowers	Blue, rose, white.	Sun, shade	Very hardy.	22
Cosmos	4+	do	Rose, pink, white.	Full sun	Hardy	16
Cypress, summer. See Summer-cypress.						
Dahlia	3	do	Red, yellow, white.	Sun	Tender	19
Daisy, African golden. See Cape-marigold.						
Delphinium. See Larkspur.						
Dianthus. See Pink.						
Dimorphotheca. See Cape marigold.						
Drummond phlox. See Phlox, Drummond.						
Dwarf marigold. See Marigold, dwarf.						
Dwarf nasturtium. See Nasturtium, dwarf.						
Euphorbia. See Snow-on-the-mountain and Poinsettia.						
Everlasting, rose. See Rose everlasting.						
Farewell-to-spring. See Godetia.						
Feather cockscomb. See Cockscomb, feather.						
Feterita	4+	Foliage	Green	Full sun	do	17
Fire plant, Mexican. See Poinsettia.						
Flame plant, Mexican. See Summer-cypress.						
Flossflower. See Ageratum.						
Forget-me-not	1	Flowers	Blue	Partial shade	Hardy	[illegible]
Four-o'clock	1½	do	Crimson, yellow, white.	Sun	Tender	[illegible]
French marigold. See Marigold, French.						
Gaillardia	2	do	Orange, crimson.	do	Hardy	[illegible]
Globe-amaranth	1½	do	Crimson or rose.	do	do	4
Glow, golden. See Rudbeckia.						
Godetia	1½	do	Rose, light purple, white.	Sun, half shade	do	4
Goldenglow. See Rudbeckia.						
Gomphrena. See Globe-amaranth.						
Grass pink. See Pink.						
Gypsophila. See Babysbreath.						
Heartsease. See Pansy.						
Helichrysum. See Strawflower.						
He[illegible]	3	do	Orange	Sun	do	3
Iceland poppy. See Poppy, Iceland.						
Impatiens. See Balsam.						
Indian corn. See Corn, Indian.						
Japanese bellflower. See Balloon-flower.						
Japanese pink. See Pink.						
Job's tears	1½	Foliage and fruit.	Green	do	Half hardy	6
Josephs-coat	3	Foliage	Red, yellow, green	Full sun	Tender	3

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.—Continued

Common name	Height of plant (feet)	Grown for flowers or foliage	Color of flowers or foliage	Preference for sun or shade	Hardiness to cold	Described on page
Kaiserblume. See Cornflower.						
Kochia scoparia. See Summer-cypress.						
Ladyslipper. See Balsam.						
Larkspur	2½	Flowers	Blue, pink, white.	Full sun	Very hardy	23
Lobelia	1	do	Blue, white	Sun	Hardy	52
Love-lies-bleeding	3	Foliage	Red	Full sun	Tender	19
Lupine	2	Flowers	Blue, rose, white.	Sun	Hardy	34
Marguerite carnation. See Pink.						
Marigold, African. See Marigold, Aztec.						
Marigold, Aztec	2	do	Yellow, orange	do	do	34
Marigold, Cape. See Cape-marigold.						
Marigold, dwarf	1	do	Golden yellow.	do	Tender	55
Marigold, French	1	do	Yellow, orange, brown.	do	Half hardy	43
Marigold, pot. See Calendula.						
Marvel-of-Peru. See Four-o'clock.						
Matthiola. See Stock.						
Mexican fire plant. See Poinsettia.						
Mexican flame plant. See Summer-cypress.						
Mignonette	1½	do	Greenish (sweet scented).	do	do	41
Milo	4+	Foliage	Green	Full sun	Tender	17
Mourning bride. See Scabiosa.						
Nasturtium, dwarf	1	Flowers	Scarlet, orange, yellow.	Sun	do	52
Nemophila	1	do	Blue, lilac, white.	Shade	Hardy	48
Niggerhead. See Rudbeckia.						
Orange sunflower. See Heliopsis.						
Painted leaf. See Poinsettia.						
Painted tongue. See Salpiglossis.						
Pansy	1	do	Purple, yellow, blue.	Shade, sun	do	54
Petunia	1	do	Rose, purple, white.	Sun	Tender	49
Phlox, Drummond	1	Flowers	Red, lilac, buff, white.	do	Hardy	44
Phlox drummondii. See Phlox, Drummond.						
Pincushion flower. See Scabiosa.						
Pink	1	do	Scarlet, pink, white.	do	do	45
Pink, Chinese. See Pink.						
Pink, grass. See Pink.						
Pink, Japanese. See Pink.						
Pink, Scotch. See Pink.						
Platycodon. See Balloonflower.						
Plumed cockscomb. See Cockscomb, feather.						
Poinsettia	2½	Foliage	Green, turning to scarlet.	do	Tender	24
Poppy	2	Flowers	Scarlet, pink, white.	do	Very hardy	37
Poppy, California. See California-poppy.						
Poppy, Iceland	1	do	Yellow, orange, white.	do	Hardy	49
Poppy, Shirley. See Poppy.						
Portulaca	1	do	Reds and yellows.	do	Tender	54
Pot marigold. See Calendula.						
Princesfeather	3	do	Red	do	do	19
Ragged-robin. See Cornflower.						
Ragged sailor. See Cornflower.						
Ricinus. See Castor-bean.						
Robin, ragged. See Cornflower.						

Some annual flowering plants, showing their hardiness, height of growth, color of flowers, etc.—Continued

Common name	Height of plant (feet)	Grown for flowers or foliage	Color of flowers or foliage	Preference for sun or shade	Hardiness to cold	Described on page
Rose everlasting	1½	Flowers	Pink and white.	Sun	Half hardy	41
Rudbeckia	2	do	Yellow, crimson.	Sun, partial shade.	Hardy	32
Sage, scarlet	2½	do	Brilliant scarlet.	Sun	Tender	25
Sailor, ragged. See Cornflower.						
Salpiglossis	2	do	Purple, crimson, white.	do	do	35
Salvia. See Sage, scarlet.						
Salvia, scarlet. See Sage, scarlet.						
Scabiosa	2½	do	Crimson, rose, blue, white.	do	do	24
Scabious, sweet. See Scabiosa.						
Scarlet sage. See Sage, scarlet.						
Scarlet salvia. See Sage, scarlet.						
Scotch pink. See Pink.						
Shirley poppy. See Poppy.						
Snapdragon	2	do	Scarlet, yellow, white.	do	Very hardy	36
Snow-on-the-mountain	2	Foliage	Green leaves with white edge.	do	do	38
Sorghum	4+	do	Green	Full sun	Tender	17
Spiderflower	3	Flowers	Rose	Sun	do	29
Standing-cypress. See Cypress, summer.						
Stock	1½	do	Crimson, purple, white.	do	Hardy	41
Strawflower	2½	do	Lemon, yellow	do	do	25
Sultan, sweet. See Sweet-sultan.						
Summer chrysanthemum. See Chrysanthemum, summer.						
Summer-cypress	3	Foliage	Pea green	do	Very hardy	26
Sunflower	4+	Flowers	Yellow	Full sun	Hardy	17
Sunflower, orange. See Heliopsis.						
Sun plant. See Portulaca.						
Sweet alyssum. See Alyssum, sweet.						
Sweet scabious. See Scabiosa.						
Sweet-sultan	3	do	Red, purple, lavender, white.	Sun	Half hardy	19
Sweet-william. See Pink.						
Tagetes. See Marigold, dwarf.						
Tasselflower. See Ageratum.						
Tom Thumb nasturtium. See Nasturtium, dwarf.						
Verbena	1	do	Scarlet, blue, purple, white.	do	Tender	35
Youth-and-old-age. See Zinnia.						
Zinnia	2½	do	Rose, scarlet, yellow, orange.	do	Hardy	28

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FARM SLAUGHTERING AND USE OF LAMB AND MUTTON

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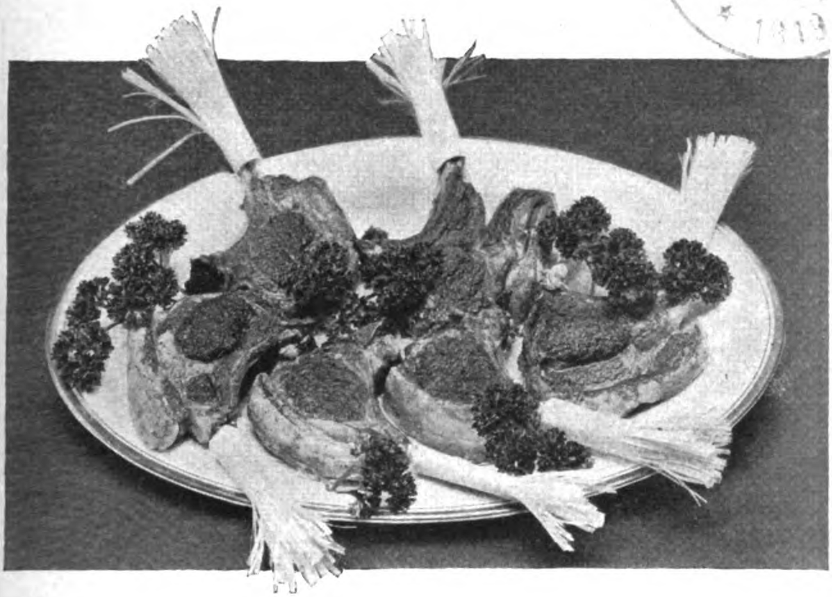
C. G. POTTS
Animal Husbandry Division



FARMERS' BULLETIN 1172
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C. **December, 1920**

WASHINGTON : GOVERNMENT PRINTING OFFICE : 19

THE PRODUCTION of sheep for wool alone is rapidly on the wane in the United States. More and more emphasis is being placed on the production of lamb and mutton for the table. The future success of this industry will depend upon a strong, steady market, based upon an increasing consumption.

Only 3.9 per cent of the meat consumed by the average American for the last five years was lamb or mutton. This proportion should be much larger, as mutton and lamb are among the most healthful, nutritious, and palatable of meats.

The ease with which sheep and lambs are slaughtered on the farm and the comparatively small size of the carcass make them a most convenient form of fresh meat for family use and for summer killing. The meat can also be cured for future use.

This bulletin contains a discussion of the methods employed in slaughtering the animal, cutting up the carcass, and curing the flesh; also recipes for cooking the meat.

FARM SLAUGHTERING AND USE OF LAMB AND MUTTON.

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USE OF MUTTON IN THE DIET.

EARLIEST records mention the use of the flesh of sheep for human food. The extent of its use, however, has varied at different times, in different countries, and even in different sections of the same country at the same time. Thus, although the United States as a whole does not use mutton and lamb extensively, a large quantity is used in a narrow section along the Atlantic seaboard north of the Potomac River.

Figures compiled in the Bureau of Animal Industry, United States Department of Agriculture, indicate that during the last five years only 3.9 per cent of the meat consumed in the United States was mutton and lamb. The average yearly meat bill (dressed-meat basis) of the American consumer during that period contains the following items:

	Pounds.
Lamb and mutton	5½
Beef and veal	66
Pork (excluding lard)	69
Total annual meat consumption per capita	140½

These figures show the proportion of lamb and mutton to other meats to be very small, and are more remarkable in view of the fact that much of this rather small percentage is consumed in the Eastern States. The sectional popularity of mutton and lamb may be seen in figures compiled from the department's estimates of sectional meat consumption.

In the East 1 pound of mutton and lamb is used for every 5 pounds of beef, in the South the ratio is 1 to 10, in the West it is 1 to 12, and in the Central or Corn-Belt States it is 1 to 20.

REASON FOR LIMITED USE.

The reason for the limited use of lamb and mutton throughout the central section of the United States probably had its origin in the days of the development of the great Corn-Belt region west of the Appalachian Mountains. At that time the sheep owned by the settlers of that region came largely from the North Atlantic States and had been developed almost without exception for wool production, regardless of the inherent flavor of the meat. The flesh of these animals was no doubt tough, not so palatable as other meats, and, possibly, owing to the crude methods of caring for it, much of it was unfit for use. And besides, the number being limited, it was necessary to retain the animals in order to have enough wool for warm clothing.

As this section of the country has been somewhat slower in the development of mutton breeds of sheep, and as much prejudice against the meat has been handed down from one generation to another, there has developed the idea that the flesh of all sheep is not appetizing and carries peculiar flavors, an opinion which a large percentage of the people never try to substantiate or disprove.

Furthermore, there is a feeling that the task of butchering a sheep is exceptionally difficult and that it can be accomplished only by some one expert in the work.

THE FLAVOR OF MUTTON.

There is a characteristic taste in cooked mutton and lamb, due to the chemical contents of the meat fat, that makes it easy to distinguish from other kinds of meat. The same is true of beef, chicken, venison, or rabbit. Eastern consumers have a liking for the peculiar flavor of mutton and lamb, and the trade has been able to sell the meat at fancy prices in that section.

Much has been said and written of the so-called "woolly flavor" of mutton and it was with a view of determining the cause and if possible the means of elimination, either in cooking or butchering, that experimental work was conducted by the Bureau of Animal Industry in collaboration with the Office of Home Economics.

These experiments included tests, as outlined below, of the most common theories advanced for the objectionable taste that occasionally occurs in mutton and lamb.

(1) Parts of carcasses were brought in contact with wool and permitted to stay in this position 30 minutes. They were then cooked and compared with similar parts of the same carcass treated in the ordinary way.

(2) Carcasses were permitted to stand and develop gas before the entrails were removed, and compared with others of the same breed and age as to the flavor and texture.

(3) The fell (or external layer of muscular tissue) was removed from some portions of carcasses and these compared with other similar portions of the same carcass and from which the fell had not been removed.

(4) Tests were made at frequent intervals on different portions of the same carcass and a check kept on the taste and texture of the meat.

(5) Comparative tests were made of sheep and lambs of different ages to note the effect of the age of the animal upon the taste.

Comparative tests were made of wool and mutton breeds to note the effect of breeds upon flavor and texture.

In only two cases was anything approaching a disagreeable flavor noted. One of these was in a rather fat part of a carcass that had been stewed and was partially cooled when sampled. This was killed in the regular way and should not have shown the flavor.

The other case of strong flavor was apparent in chops kept 10 days in the cooler and kept to the verge of spoiling, outside, before cooking. This taste was most pronounced in the outer layer of fat and was no doubt due to some chemical change which had taken place in that portion of the meat.

In some cases, when the meat was cooked without removing the fell, the latter when tasted separately was less pleasant than the meat itself.

It can not be denied that in rare cases meat sold as lamb or mutton has an objectionable taste. This may be due to the fact that the carcass was in reality that of an old ram or goat. Holding the meat for a long time, particularly in the presence of odors of decaying vegetables or other matter, may also cause an unpleasant taste. Leaving the fell on the cooked meat also increases the possibility of the undesirable taste developing.

With reasonably careful slaughtering and caring for the lamb or mutton carcass, as described in the following pages, there is a practical certainty of having wholesome, appetizing, and economical meat for family use.

WHY MORE MUTTON AND LAMB SHOULD BE USED.

Possibly the first reason for urging the more extensive use of mutton and lamb may be found in the nature of the sheep industry itself. The old method of raising sheep for wool alone is rapidly on the wane in the United States. The method developed in the last decade in the farm States is rapidly increasing. This industry is being conducted for the production of both wool and lambs, and as the increased production of wool is essential to the normal development of the country, it is necessary that a market for the meat be developed in proportion to the increase in the production.

Food Value.—The fact that mutton and lamb are well liked, easily digested, rank well with other meats as regards nutritive value, and are palatable, wholesome, and usable in many ways has long been known. The following table shows the percentage composition and fuel value per pound of lamb, mutton, and some other meats:

Average Composition of Meats

Meat (as purchased).	Protein.	Fat.	Water.	Refuse.	Fuel value per pound.
Lamb:	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Breast	15.4	19.1	45.5	19.1	1,075
Leg	15.9	13.6	52.9	17.4	860
Mutton:					
Fore quarter	12.3	24.5	41.6	21.2	1,235
Hind quarter	13.8	23.2	45.4	17.2	1,210
Veal:					
Fore quarter	15.1	6.0	54.2	24.5	535
Hind quarter	16.2	6.6	56.2	20.7	580
Beef:					
Fore quarter	14.5	17.5	49.1	18.7	995
Hind quarter	15.4	18.3	50.4	15.7	1,045
Pork (fresh):					
Ham	13.5	25.9	48.0	10.7	1,320
Shoulder	12.0	29.8	44.9	12.4	1,450

The table above is from Farmers' Bulletin 142, Principles of Nutrition and Nutritive Value of Food.

Freedom from disease.—The fact that a smaller percentage of sheep carcasses as compared with those of other commonly used domestic animals is condemned under the Government meat inspection still furthers the opinion that mutton and lamb are the most wholesome of meats and should be in more general use.

Because of the foregoing evidence and the fact that mutton provides a convenient source of fresh meat in sections where beef is unobtainable most seasons of the year, the following directions for the farm butchering of sheep have been prepared.

SLAUGHTERING AND DRESSING SHEEP.

Equipment.—The only equipment necessary for butchering a sheep is a knife for sticking and skinning, a steel or stone to sharpen the knife, a place to hang the animal up, and a clean place in which to work. This last may be a killing box, a low platform, table, or a tough, heavy sod, sloping so that the blood will drain away from the slaughtered animal.

Condition of animal.—The animal should be in good flesh but not too fat. It should be healthy, in perfectly normal condition, and not be excited before killing. Care should be taken never to strike the animal or catch it by the wool, as either will leave ugly bruises on the carcass.

It should be kept off feed, both grain and roughage, for at least 18 hours before slaughter, to prevent development of gases in the stomach and intestines, thus lessening the danger of cutting them when the entrails are removed. Free access to water before killing is desirable, as it facilitates the slipping of the skin.

Sticking.—The animal is caught and laid on its back. The two front feet are bent back while the left hind leg is brought forward. The three feet are tied together. The animal is then laid on its left side and the nose grasped with the left hand. The knife is stuck into the neck a little below the right ear and just back of the jawbone. (Fig. 1.)

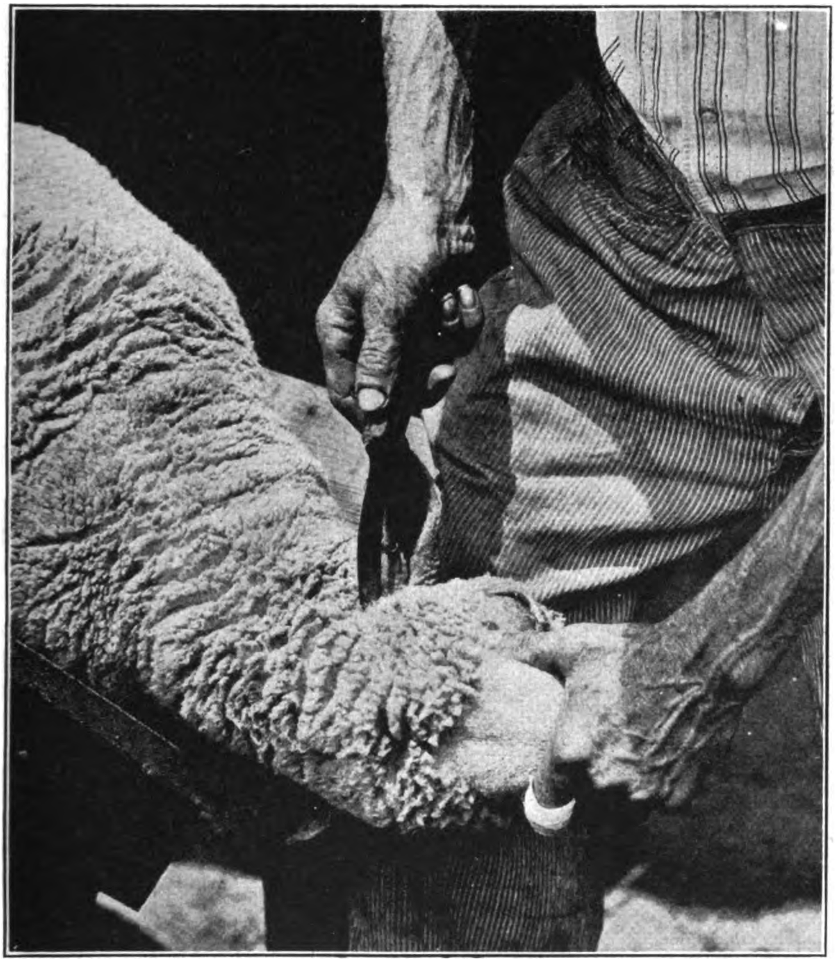

Fig. 1.—Sticking the animal.

A sharp, thin-bladed knife should be used and thrust completely through the neck. The sharp edge should be outward. The under portion of the neck can then be completely severed with an upward and outward motion.

Stunning.—The neck is then immediately grasped with the right hand just back of the incision and by a quick pressure with the left hand on the nose the neck is broken over the edge of the box (fig. 2), stunning the animal and facilitating the thorough bleeding out of the carcass.

Skinning.—After the sheep has thoroughly bled, it is ready to be legged out. This operation may be performed with the animal on the ground or by the operator climbing on the platform. The foot is held between the butcher's knees and the skin on the upper foreleg grasped with the left hand. If care is used a narrow strip can be run down to the foot (fig. 3), where the joint is severed. After the other leg has been similarly treated, the skin is opened across the breast and removed from each side of the neck, the knife being used in the operation. It is then fisted off over each side of the brisket and back of the

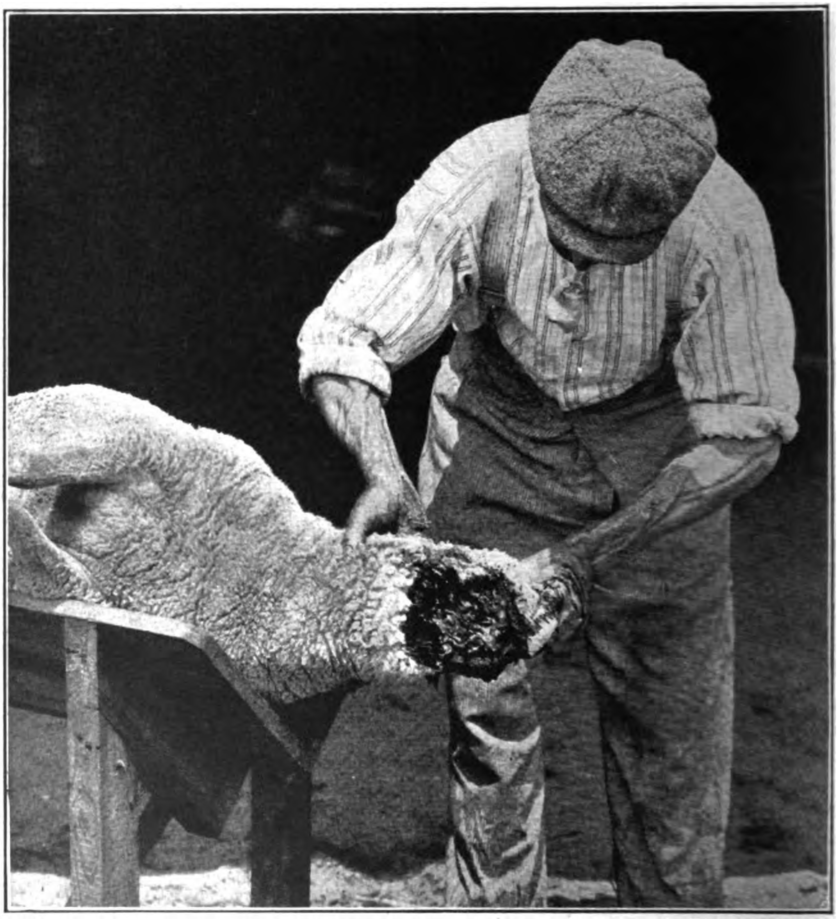

FIG. 2.—Stunning the sheep.

forelegs (fig. 4). This same method is used in removing the skin from the forearm, after which it can be easily stripped from the rest of the leg.

Following this the throat is slit and the gullet (esophagus) removed. The outer or fleshy part of this should be broken by drawing it between the thumb and back edge of the knife. It can then be tied so that no material or gas can escape from the stomach (fig. 5).

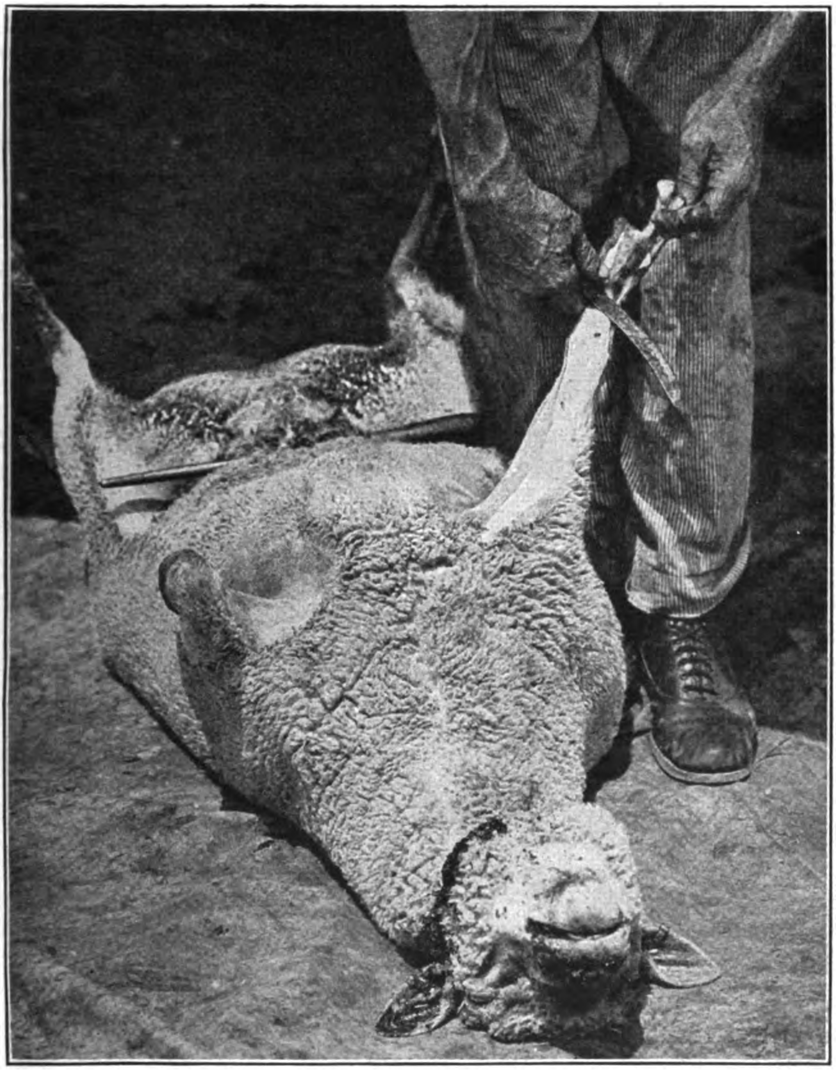

FIG. 3.—Opening the skin.

The hind legs are legged out in much the same way as the forelegs. A strip of skin is removed from the rear of the leg from a point near the body to the foot. (Fig. 6.) The skin is then opened to a point near the anus and removed up or over the breech, the knife being used in the process, as shown in figure 7. After a similar opening has been made in the other leg, the skin is removed from between the legs and fisted down over the belly. (Fig. 8.) It is next loosened around the leg and may be rapidly run down to the joint below the pastern, where the foot is severed. The knife is then passed through the hind lègs, between the ankle and hock. A cord is tied through this opening by which the carcass may be suspended. The animal is then ready to be hung up. (Fig. 9.)

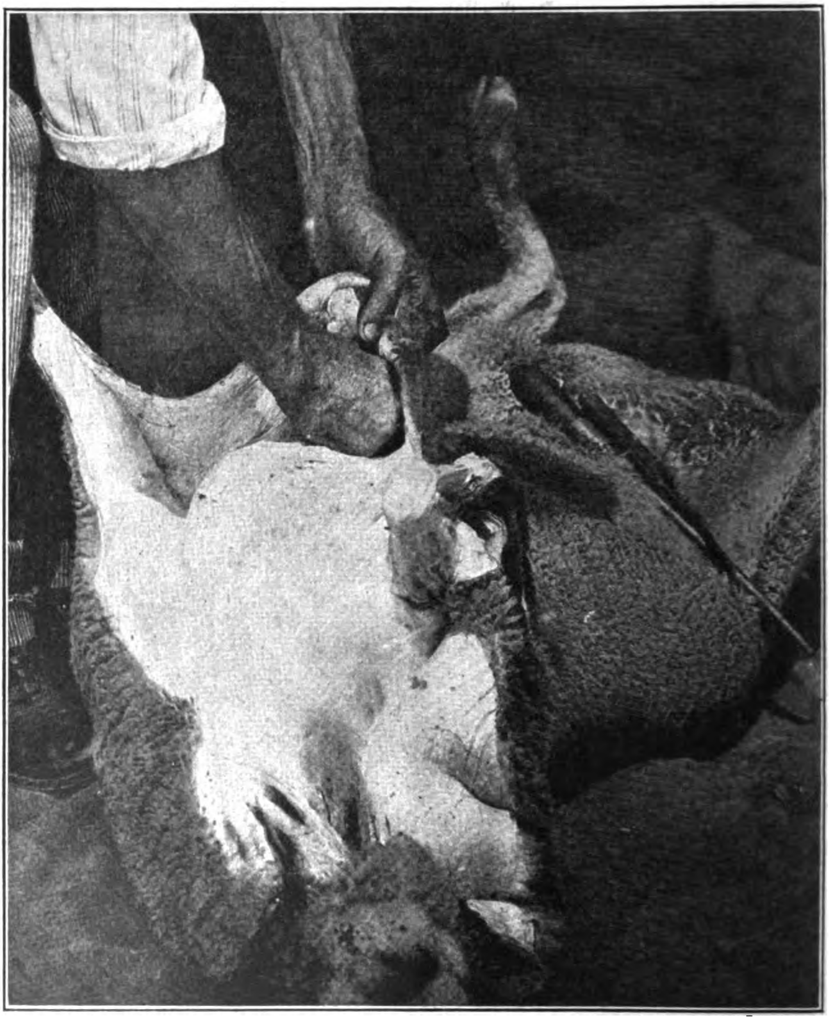

FIG. 4.—"Fisting off" skin over the brisket.

After that the skin is opened down the mid line, then with the point of the knife it may be loosened out over the flank, where extreme care must be taken not to tear the flank muscles. (Fig. 10.) Beginning in the mid part the skin is next fisted out over the sides up over the thigh and down over the shoulder. (Fig. 11.)

Figure 12 shows the method employed in removing the skin from the sides of the animal; it may be beaten down very rapidly in this way. Should any muscles begin rolling with the skin, however, the point of laceration should be worked around and the flesh removed in the opposite direction from which it is tearing. The skin is removed from around the tail with the knife, and then the operator by grasping it with the right hand and pressing the left against the carcass, can

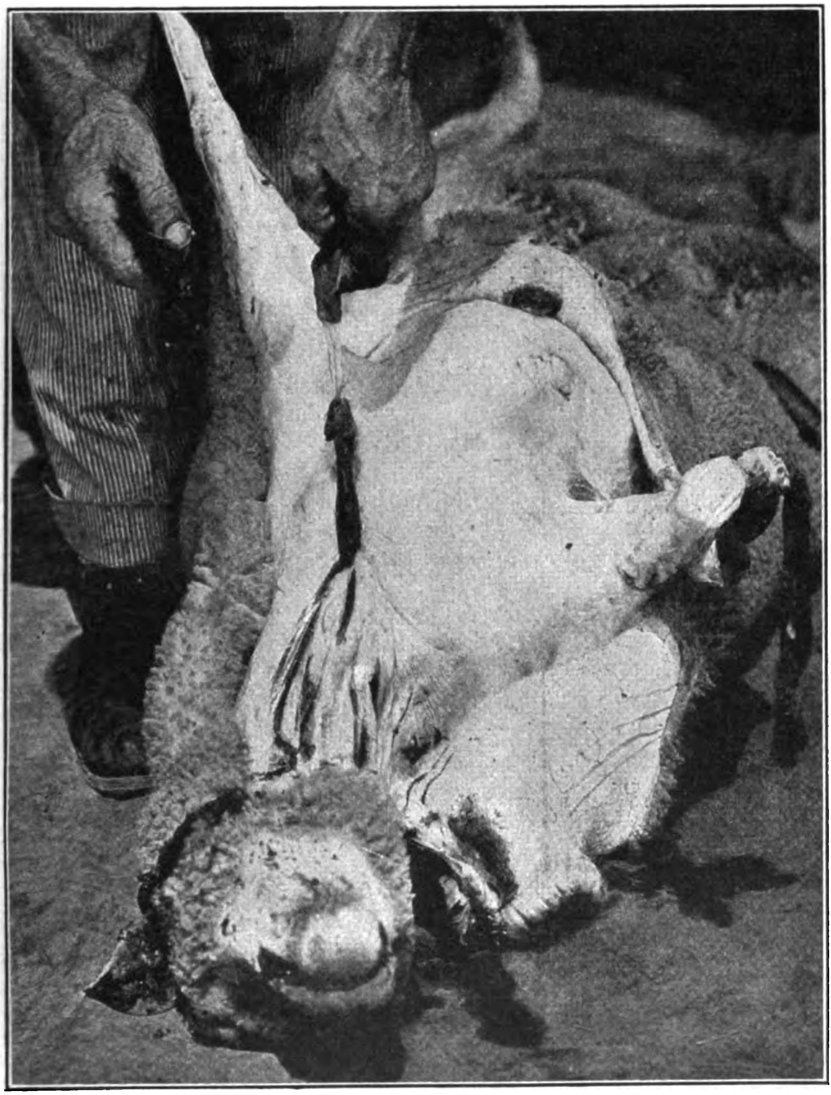

FIG. 5.—Tying the gullet (esophagus).

easily strip it down the back to the neck, where it is usually severed with the knife. The head is then removed at the atlas joint. (Fig. 13.)

Removing the entrails.—In removing the intestines the rectum is first cut around and the colon drawn out from 6 to 8 inches, where it is cut off. Incision is made at the cod or udder and the carcass opened down the middle to the breastbone. It is well to hold the carcass away from the intestine and paunch by inserting the two forefingers of the left hand, then pushing them down so that the abdominal covering may be cut as it is held out by the finger. (Fig. 14.) The intestines and paunch will then drop forward but are held in place by attachment to the back. The caul fat should then be removed. Then by working around underneath the paunch the gullet may be grasped and withdrawn, after which the intestines may be entirely removed by severing the connection with the back.

Removing the pluck.—The knife should then be inserted into the throat to facilitate the thorough bleeding of the thoracic cavity. (Fig. 15.) This will keep the carcass free from bloodstain when the pluck is removed, which process is accomplished by splitting the breastbone with the knife and cutting around the diaphragm. The pluck is then free to drop forward and be removed. The forearm is next split and the leader drawn out. After the knee has been bent back, the leader is passed over the lower cannon bone to hold it in position. This gives the carcass a neat, plump appearance. (Fig. 16.)

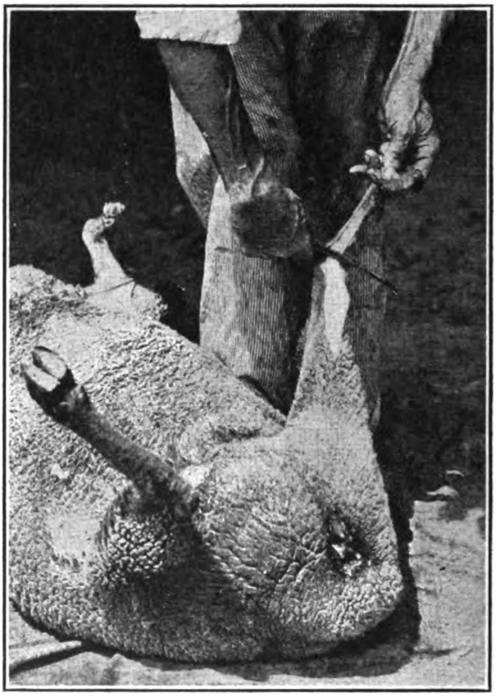

FIG. 6.—Opening skin on hind leg.

CARE OF THE CARCASS.

Cooling out.—After the removal of the entrails, the carcass should be washed thoroughly with either warm or cold water. Warm water has a tendency to bleach the carcass. Cold water should be used in warm weather, as it aids materially in reducing the temperature. The carcass should then be wrapped in cheesecloth and hung in a cellar, or any clean, cool place that is free from disagreeable odors.

CUTTING UP THE CARCASS.

The carcass cuts better after it has been thoroughly cooled out, although cooling is not absolutely necessary. Besides the knives used in slaughtering and dressing, the only materials necessary for this work are a saw and a cleaver. (Fig. 17.) The method of cutting generally used is called saddling the carcass. (Fig. 18.) The cut is made so as to leave one rib on the hind quarter or "short saddle." The remainder of the carcass is called the fore quarter or "market rack."

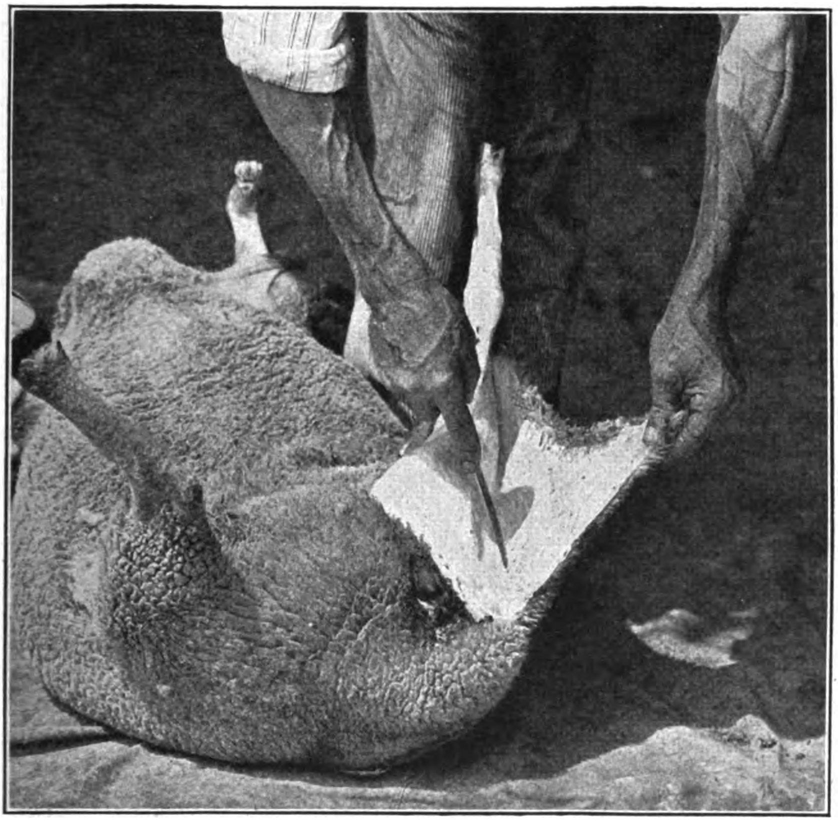

FIG. 7.—Removing skin from the hind leg.

The short saddle is then divided along the backbone, beginning at the tail and splitting the backbone with either the saw or cleaver. (Fig. 19.) The loin should be separated from the leg, leaving 8 to 10 vertebræ in the loin cut, the place depending on the size of leg wanted. All the meat should be cut with the knife, the saw being used only to cut the bones. (Fig. 20.) The loin is then either cut into chops from three-fourths to 1 inch thick or used whole for roasting. (Fig. 21.)

The leg.—The leg is trimmed of the thin flank muscles and the excess fat; the shank is removed a short distance above the hock and the meat trimmed from it, leaving 1 inch of the lower end of the bone free from covering. Other ways of fixing this cut are to remove the bone at the stifle joint and wrap the meat removed from the shank bone over and skewer it down, or by entirely removing the bone and fastening the meat in a roll with skewers. Most of the trade prefer the tail bone left on the roast. Figure 22 shows a leg prepared for roasting.

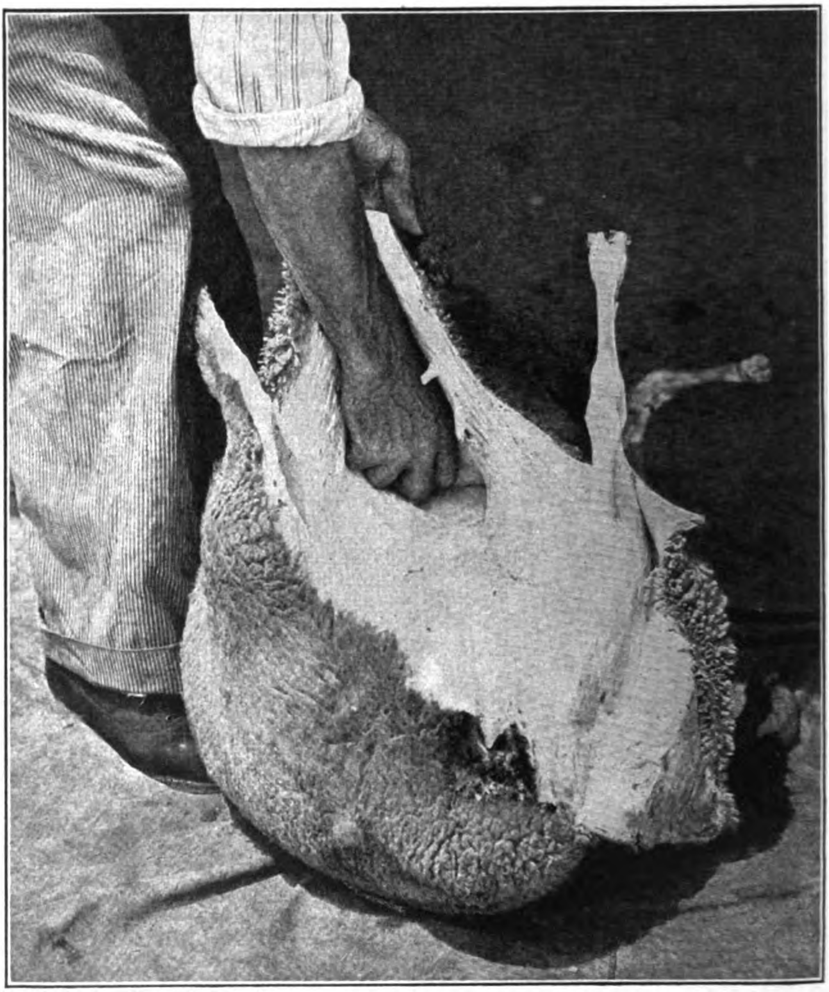

FIG. 8.—"Fisting off" the skin from the belly.

Fore quarter or "Market rack."—The fore quarters are usually divided by sawing down the backbone to the neck, which is then completely severed with the cleaver. (Fig. 23.)

Shoulder.—The shoulder of mutton is lifted by cutting around the fleshy part from the backbone near the neck, back to the fifth rib, and then passing the knife under the shoulder blade. (Fig. 24.)

Boning the shoulder.—In this operation the shoulder is laid on the table with the outside down and the bone removed by cutting around it lengthwise, beginning at the fleshy part just above the knee. A sharp, thin-bladed knife is essential for this work. (Fig. 25.) After the bones are removed the meat is rolled and held in place by skewers or sewed. This makes a delicious roast which is free from bone and therefore easily sliced. (Fig. 26.)

The remainder of the fore quarter is then sawed through on a line parallel to the backbone and about 6 or 7 inches distant from it. The lower part of this cut is called the breast and is utilized as stew meat. What is left of this quarter is divided between the fourth and fifth ribs, the portion between the loin and fourth rib being known as "rib cut" or rack. (Fig. 27.) This is usually divided into rib chops of one rib each, although it may be used for roasting. When the chops are used without other trimming than the removal of excess fat, they are called "plain rib" chops. They are sometimes trimmed back about 2 inches from the lower end of the rib and are then called French chops. The trimmings are used for stew.

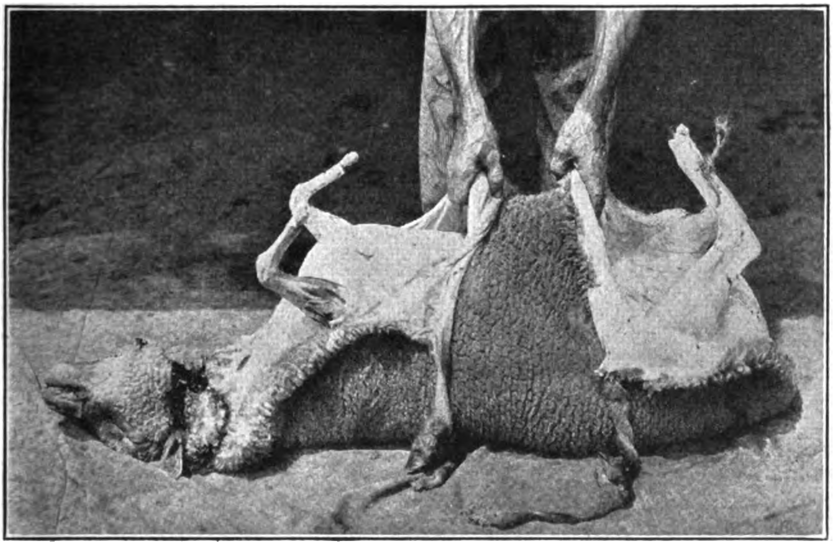

FIG. 9.—Skin entirely removed from belly. Carcass ready to be hung up.

Shoulder chops.—The remaining ribs in this strip are cut into shoulder chops while the neck is used for stew. (Fig. 28.)

CUTTING UP A LAMB CARCASS.

Figure 29 indicates the usual method of cutting up the carcass of a lamb. The cuts as they come in order are: Leg, loin, rack, shoulder, and breast. They are utilized in practically the same way as mutton, and what has been said as to the preparation of mutton is also applicable to lamb, except as to the boning of the shoulder, which in the case of lamb is done as follows:

The round bone is easily removed by cutting around to the point at which it joins the shoulder blade. The shoulder is next stood on the backbone edge and the shoulder bone is pounded in the joint with the back edge of the cleaver. In this way the cartilage is broken loose around the edge of the blade. Then by using the steel the operator loosens the meat from the upper and under sides. The blade may then be withdrawn from the shoulder, which is easily removed from the backbone and ribs by passing a knife between the bones and the meat. Being thus free from the bone the meat may be roasted and sliced without difficulty. (Fig. 30.)

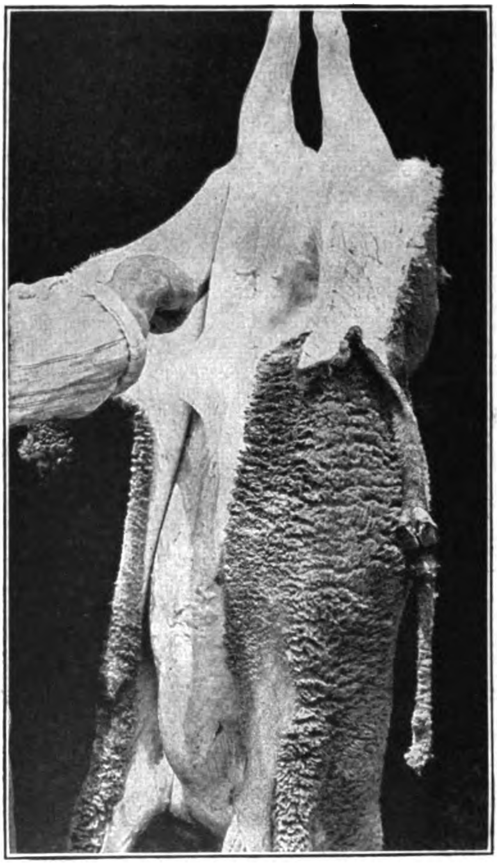

FIG. 10.—Skinning out over the flank.

Another method of boning a lamb shoulder is to remove the ribs first. Then by cutting around the top and back edges of the shoulder the blade and gristle may be removed, after which it is rolled either with or without stuffing and sewed or fastened with skewers to hold it in place. This is probably the quickest and easiest method of preparing a boned shoulder roast.

HOME CURING OF MUTTON.[1]

The first essential in curing is to be sure that the meat is thoroughly cooled. The meat should never be frozen, either prior to or during the period of curing. The time to begin curing is when the meat is cooled and still fresh; the proper time is from 24 to 36 hours after killing. Because of the high shrinkage experienced in curing, only large pieces such as the legs and shoulders are suitable for treatment.

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[1] Formulas furnished by G. A. Anthony, Animal Husbandry Division.

BRINE-CURED MEAT.

Many different formulas may be used for curing mutton by the brine method, but the recipe given below if followed closely will give good results. For each 100 pounds of meat use:

7 pounds salt.
2½ pounds sugar or sirup.
2 ounces saltpeter.
4½ gallons water.

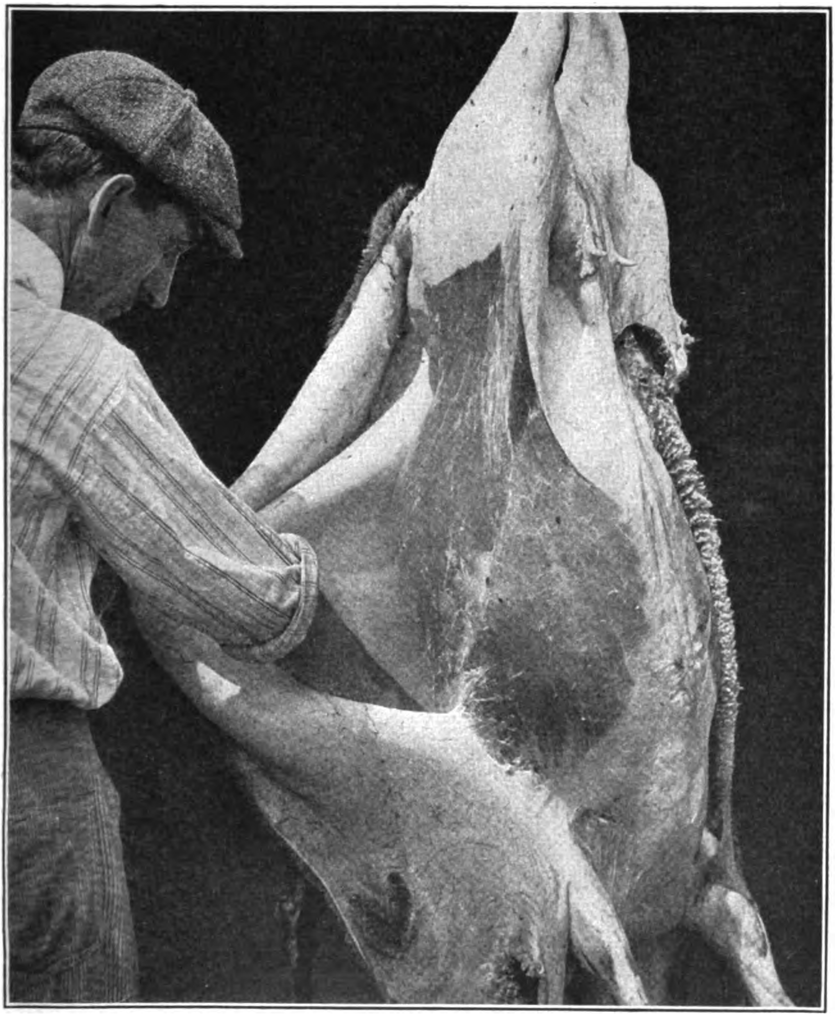

FIG. 11.—"Fisting" skin over side and shoulder.

In warm weather it is better to use 9 or 10 pounds of salt.

All the ingredients are poured into the water and boiled until thoroughly mixed. The brine should be made the day before it is used, so that it will be cool. Place the legs in the bottom of the container, shoulders next; the small cuts should be on top. Be sure to weight down the contents with a stone or a brick. Iron should not be used, as it will rust. Pour the brine in and be sure it covers the meat thoroughly. In one week pour off the brine and change the meat, placing the top meat on the bottom and the bottom meat on top; then pour the brine back. Repeat this operation at weekly intervals. If the pickle becomes ropy, take out all the meat and wash it and the container thoroughly. Boil the ropy pickle or, better, make new pickle. If the old pickle is boiled, it should be strained before boiling.

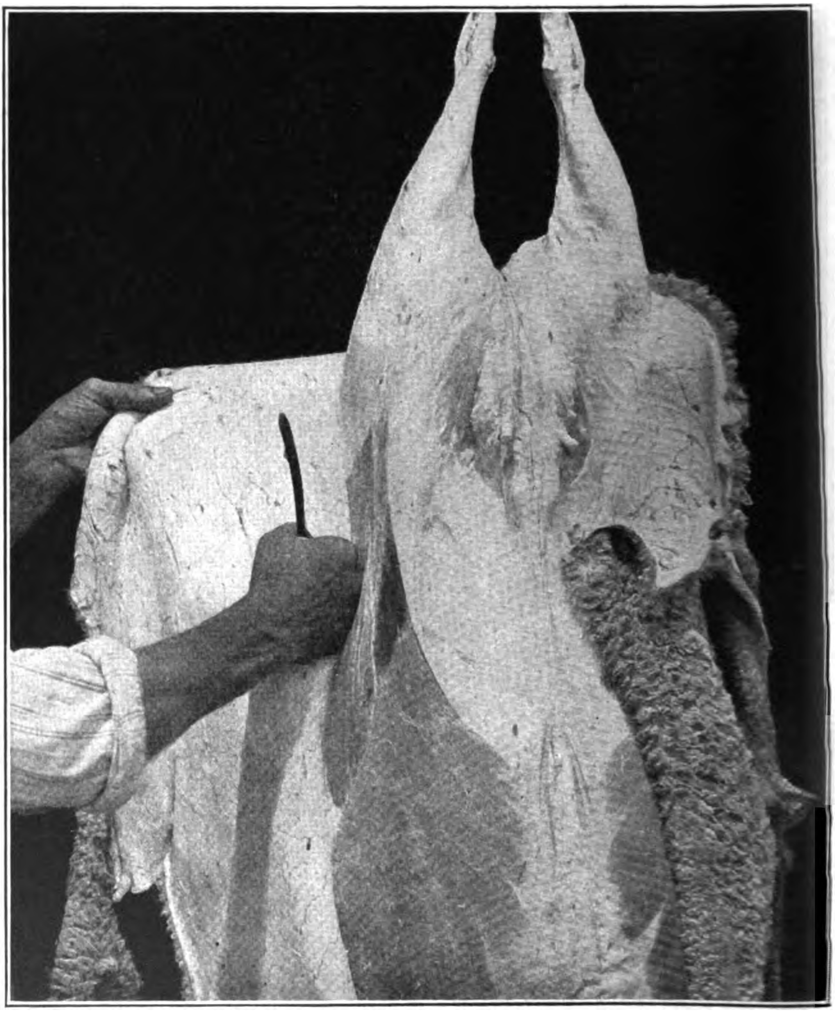

FIG 12.—Pounding the skin down the side.

Allow 3 days' cure for each pound in a leg or shoulder; for example, a 10-pound leg will take 30 days. Smaller pieces take a proportionately shorter time. When each piece of meat has received the proper cure, take it out of the pickle, string, and hang it in the smokehouse. The temperature of the smokehouse should not exceed 125° F. Smoke the meat until it has a good chestnut color.

In preparing meats in this manner it has been found more convenient to brine-cure the light pieces and dry-cure all the larger ones. The reason is that the smaller pieces shrink considerably when dry-cured and leave only a comparatively small portion of meat.

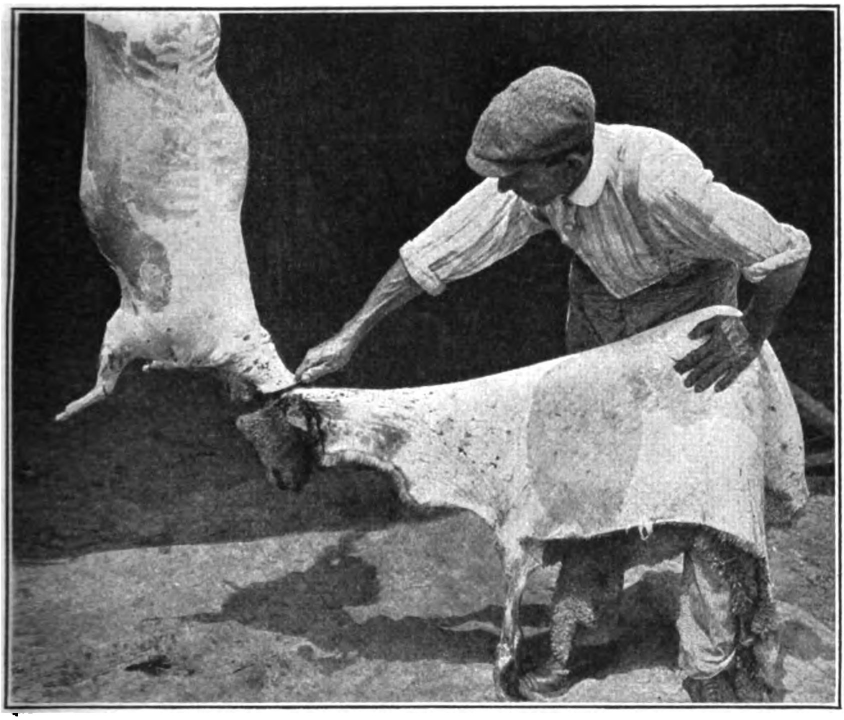

FIG. 13.—Removing the head and the hide.

DRY-CURED MEAT.

Dry-cured meat is better for future use than the brine-cured and requires less work. However, danger from rats and other vermin is less in the case of brine-cured meat. Both methods of curing are very successful if care is taken to see that each operation is executed properly. Following is the method of dry-curing. For each 100 pounds of meat use:

7 pounds	salt.
3 pounds	sugar or sirup.
2 ounces	saltpeter.
2 ounces	red pepper.
3 ounces	black pepper.

Mix all ingredients thoroughly, then rub the mixture well over the meat and pack it away in a box or on a table. Allow 1½ days' cure for each pound of meat the pieces average. After the meat is cured hang it in the smokehouse.

RECIPES FOR COOKING MUTTON AND LAMB.[1]

MUTTON BROTH.

3 pounds mutton.
2 quarts water.
3 tablespoons rice or barley.
Salt to taste.

The neck, breast, and flank are generally used in making broth, although other cuts may be used. Remove the outside papery skin from the cut when present and wash well with cold water. Cut the meat into small pieces and remove the excess fat. Put the meat with bones into the kettle and cover with water. Heat gradually to the boiling point and season. Cook slowly until the meat is tender, then strain, and remove fat. Reheat to boiling point and add rice or barley and cook till cereal is tender. If barley is used, it should be soaked over the preceding night in cold water.

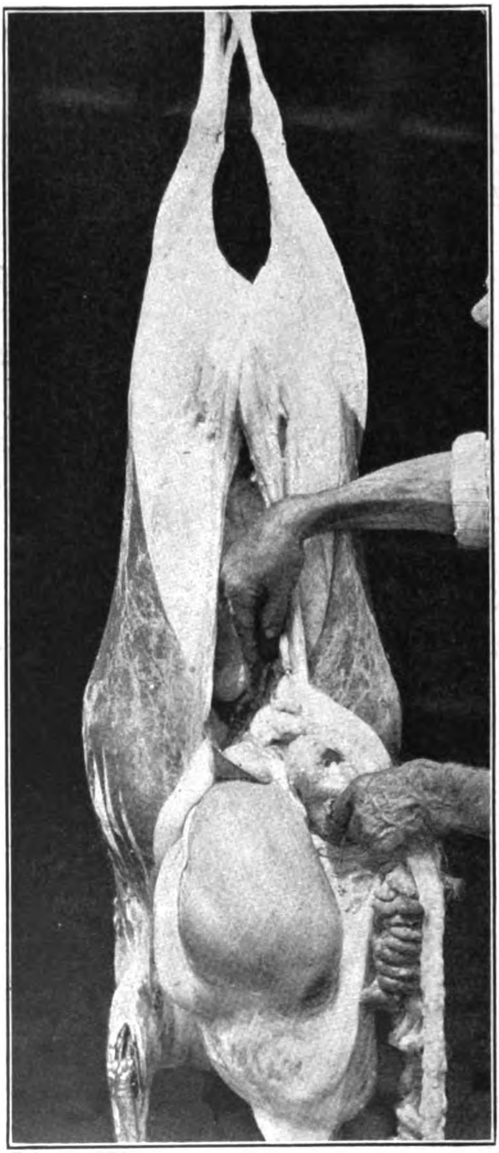

FIG. 14.—Loosening entrails from the backbone.

MUTTON SOUP.

4 pounds mutton.
3 quarts water.
3 carrots.
2 turnips.
1 small cabbage.
1 stalk celery.
Few sprigs parsley.
1 onion.
6 cloves.
1 sprig thyme.
1 sprig marjoram.
2 tablespoons salt.

Remove the papery skin of the meat, wipe well with damp cloth and cut into small pieces, put into a kettle and cover with water. Bring slowly to boiling point and skim; add vegetables cut into small pieces and other seasoning, and cook slowly for 3 hours. Strain, cool, and remove the fat. Serve either clear with rice or with the other vegetables finely chopped.

CURRY OF MUTTON.

2 pounds mutton.
1 onion.
1 teaspoon vinegar.
2 tablespoons flour.
1 teaspoon curry powder.
Salt.
Boiling water.

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[1] Taken from Farmers' Bulletin 526, "Mutton and Its Value in the Diet."

This dish may be prepared from the neck, flank, chop, trimmings, or breast. Remove fell when present and wipe with damp cloth. Cut into pieces 2 inches square and remove portions of the fat. Fry them out and remove solid portion. Place meat in the remainder and fry to delicate brown. Add sliced onions and pour on barely enough boiled water to cover. Cook until the meat is tender. Add the curry powder, vinegar, and salt. Remove the meat, reduce the broth to 1 cup, and thicken with flour diluted with cold water. Add meat to gravy and reheat. Serve with rice.

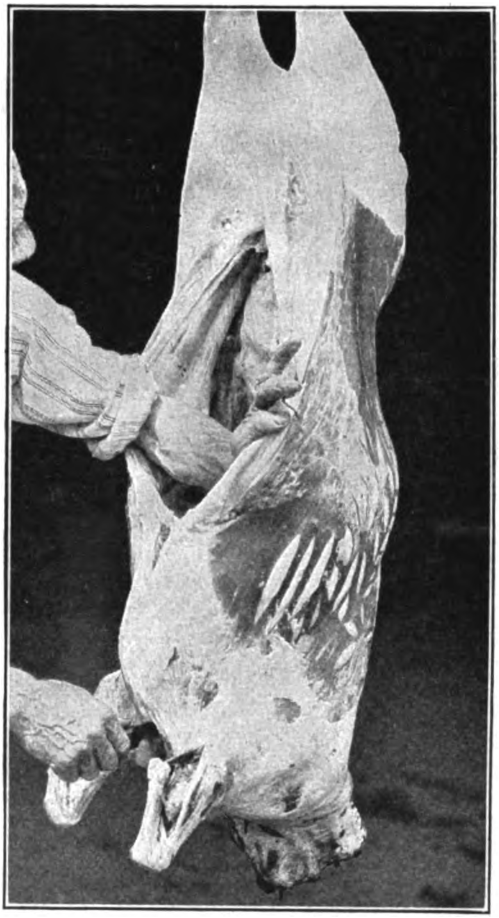

FIG. 15.—Draining the thoracic cavity.

STEAMED MUTTON.

Small pieces of mutton may be cooked very satisfactorily by steaming. Mix the following and spread over the surface, then wrap in cheesecloth and fasten with skewers:

1 clove of garlic, finely chopped.
1 finely chopped onion.
1 teaspoon powdered thyme.
1 teaspoon powdered sweet marjoram.
1 teaspoon salt.

BRAISED LEG OF MUTTON.

1 leg mutton.
½ medium-sized onion.
1 carrot.
1 turnip.
½ bay leaf.
1 sprig each thyme and parsley.
¼ cup mutton drippings or butter.
1½ teaspoons salt.
12 peppercorns.
3 cups hot water.

Have the leg of mutton boned. Wipe, stuff with the mixture described below, sew, and place in a deep pan. Cook the onion (sliced), the carrot, and the turnip (cut into dice), bay leaf, thyme, and parsley 5 minutes in the butter or mutton drippings. Add the hot water, salt, and peppercorns and pour the mixture over the mutton. Cook slowly for 3 hours, with the dish covered except for the last half hour. Make a brown gravy out of the strained broth in which the meat has been cooked (see below).

STUFFING FOR BRAISED LEG OF MUTTON.

The stuffing for the braised leg of mutton is made as follows:

1 cup cracker crumbs.
2 tablespoons melted butter.
¼ teaspoon salt.
⅛ teaspoon pepper.
½ teaspoon poultry seasoning.
¼ cup boiling water.

SHOULDER OF MUTTON BRAISED WITH TURNIPS.

6 pounds of mutton from the shoulder.
1 onion.
1 carrot.
1 stalk celery.
4 cloves.
½ bay leaf.
1 quart water.
6 turnips.
Salt.

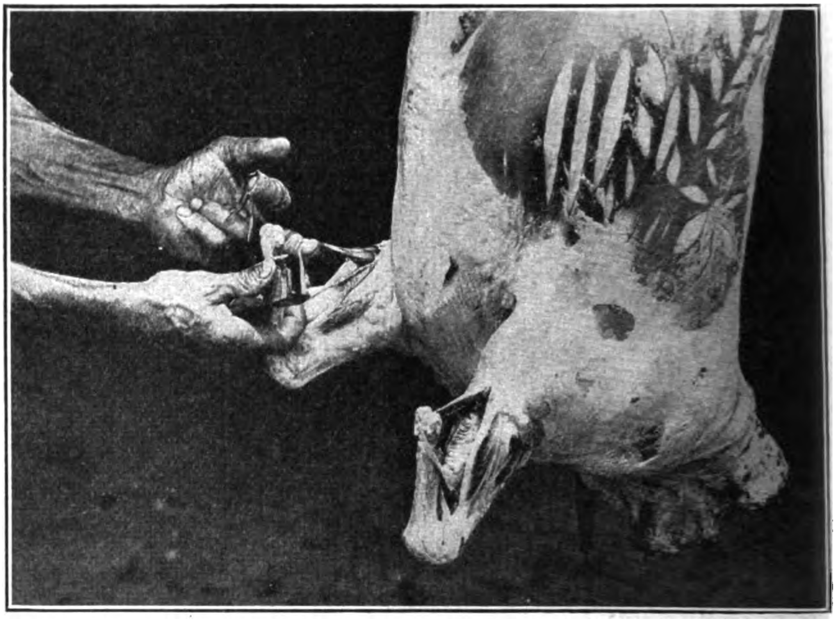

FIG. 16.—Doubling back the forelegs.

Cut the onion, carrot, and celery into small pieces and put them with the shoulder of mutton into a deep baking pan. Cover, and allow the mutton juice to permeate the vegetables and brown with them in the oven. Then add the water, cloves, and bay leaf. Cook in a moderate oven until the meat is tender, which will be about 3 minutes for each pound. One hour before serving add the turnips, which have been peeled and parboiled.

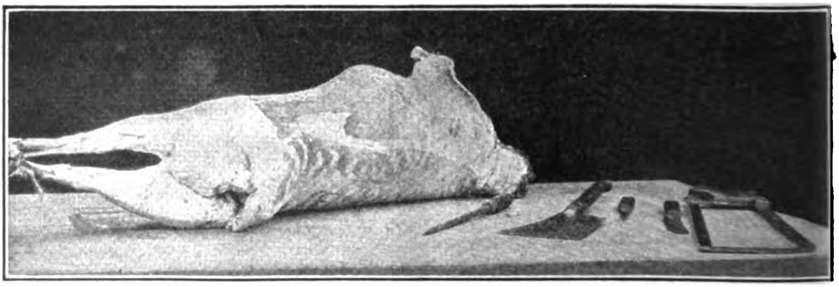

FIG. 17.—Equipment for cutting up the carcass.

BRAISED BREAST OF MUTTON.

1 breast mutton.
Few slices bacon.
½ pint stock.
1 lemon.
1 onion.
Salt.

Line the bottom of a casserole or other earthenware baking dish with a few thin slices of bacon, lay the mutton on them, and put over it the lemon, which has been peeled and cut into slices. Cover with 1 or 2 more slices of bacon and add the stock and onion. Cover the dish. Cook slowly on the top of the stove or in the oven until the meat is tender.

ROAST LEG OR SHOULDER OF MUTTON.

Sprinkle the meat with salt and pepper, place upon a rack in the baking pan, and dredge with flour. Bake in a hot oven, basting frequently. Allow 20 minutes to the pound, unless the roast is very small. Reduce temperature sharply to moderate heat as soon as meat has become seared on outside.

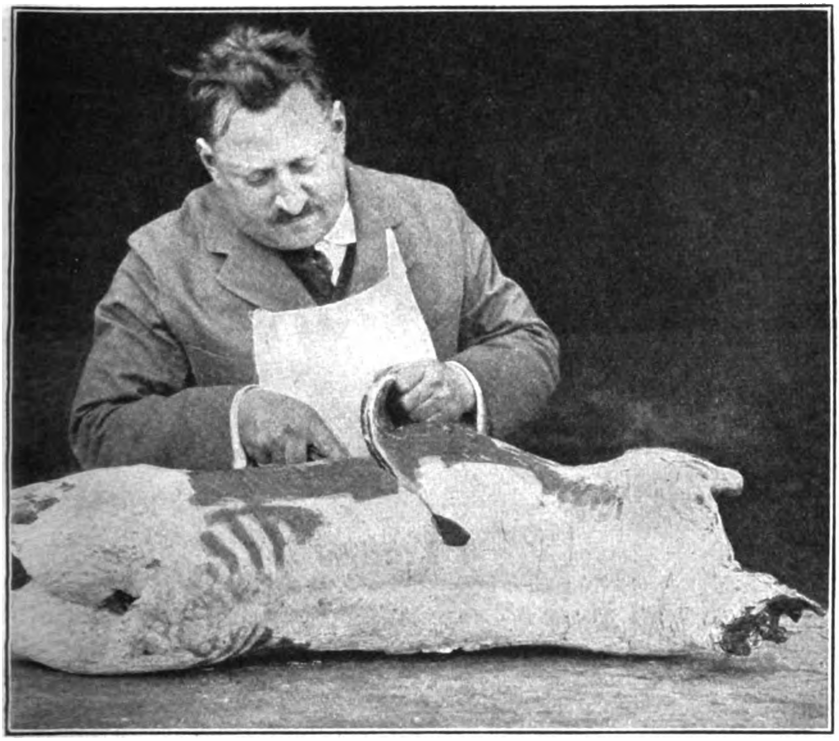

FIG. 18.—Removing short saddle.

BROWN GRAVY FOR ROAST MUTTON.

In making gravy for roast mutton or any other roast meat, allow 2 level tablespoons of fat for each cup of gravy desired, pouring off any in excess of that amount. To the fat add 3 tablespoons of flour for each cup of gravy and cook thoroughly, browning it, but being very careful not to burn it. Add boiling water or broth and boil for a short time, stirring constantly. Add salt and pepper. The proportions are 2 tablespoons of fat, 3 of flour, and 1 cup of water or stock. If the flour is not browned, only 2 level tablespoons are needed for each cup.

CURRANT-JELLY GRAVY.

A gravy flavored and made acid with currant jelly is often served with roast mutton. To each cup of brown gravy made from the fat of roast mutton add a glass or less of currant jelly. The addition of currant jelly is especially suitable when cold mutton is to be warmed up in gravy.

MUTTON STUFFED AND ROASTED.

For this purpose have either the leg or shoulder of mutton boned. Stuff the boned piece and tie into good shape. Roast in a hot oven, allowing about 20 minutes to the pound. Add to the dressing more fat, unless the meat is very fat. In making the gravy, follow the directions given above.

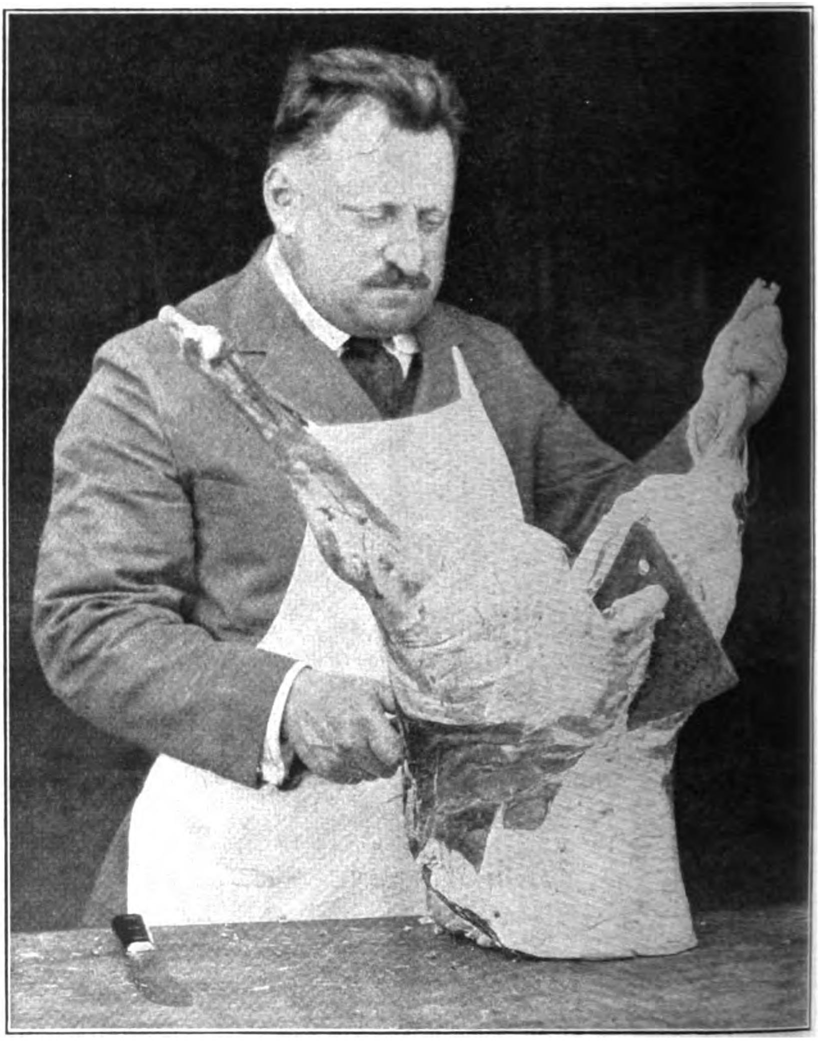

FIG. 19.—Dividing the rear part.

DRESSING FOR ROAST MUTTON.

- 1 pint stale bread crumbs.
- ½ cup cracker crumbs.
- ½ teaspoon sage.
- 2 tablespoons butter.
- 1 teaspoon sweet marjoram.
- Salt and pepper.
- Few drops onion juice.

Cook the bread in cold water; press out nearly all the water, and add the other ingredients.

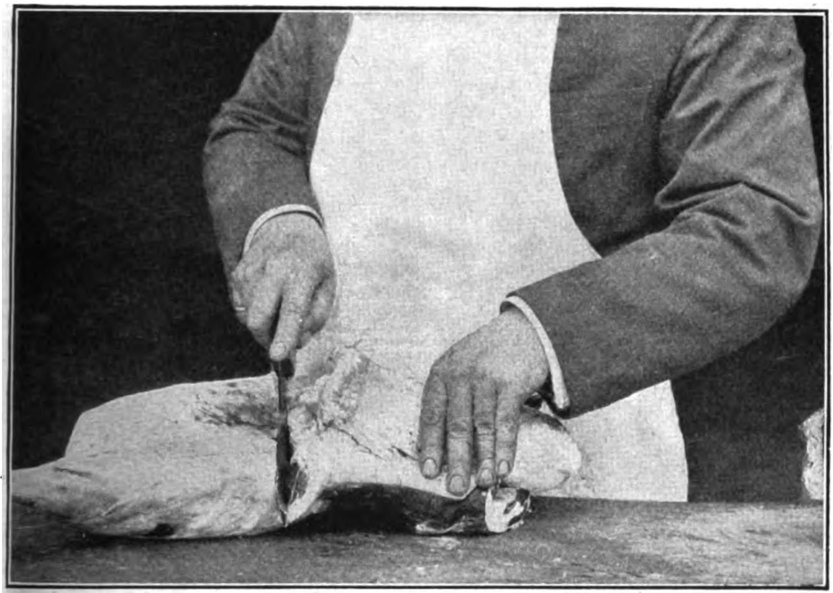

FIG. 20.—Removing the loin.

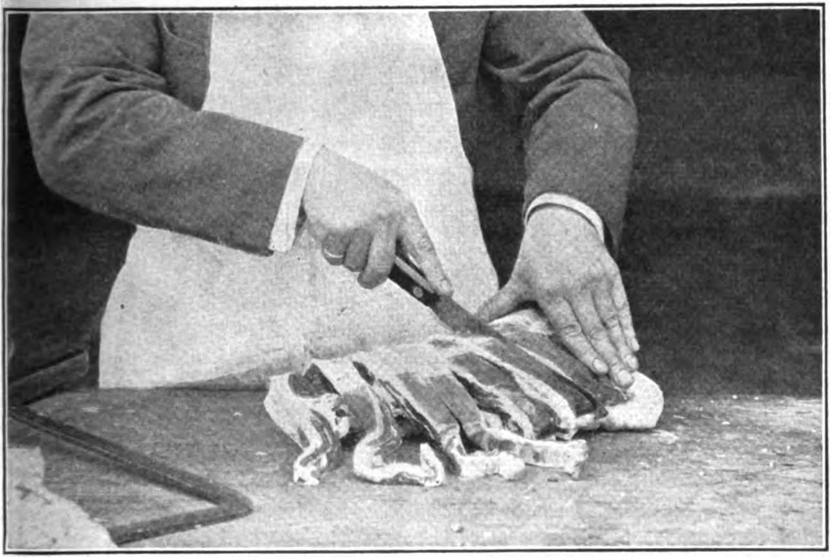

FIG. 21.—Cutting loin chops.

BROILED LOIN CHOPS.

Remove superfluous fat and roll the flank about the tenderloin, fastening it with skewers. Place on a broiler greased with some of the mutton fat. Cook in hot oven 6 to 8 minutes, turning frequently during the first part of the time and reducing the heat as soon as the meat is well seared. A sauce of butter to which a little lemon juice and chopped parsley have been added is sometimes rubbed over the chops. Since the chops themselves contain much fat, lemon juice and parsley only may be used, or the chops may be served on thin slices of lemon. Some people consider onion sauce a great delicacy for serving with broiled chops.

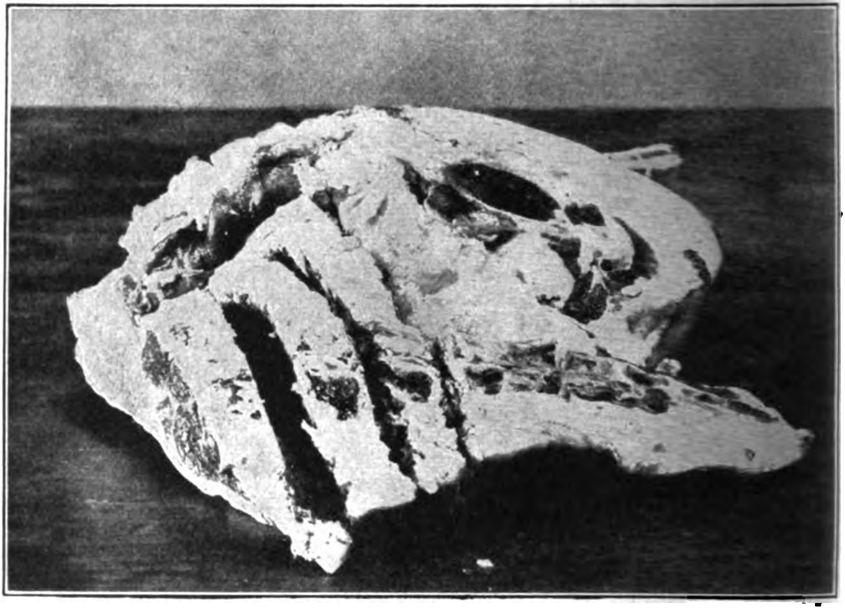

FIG. 22.—Leg of mutton ready to roast.

ONION SAUCE.

8 large white onions.
¼ cup butter.
1 tablespoon flour.
1 teaspoon sugar.
½ cup cream.
Salt.

Cut the onions into 2 or 3 pieces each and cook them for 10 minutes in boiling salt water. Strain and cook in a covered saucepan with the butter for about three-quarters of an hour until they are very tender. Press through a purée sieve and reheat. Sprinkle the flour over them, stirring it in thoroughly, and add the seasoning. Bring to the boiling point and heat long enough to cook the flour thoroughly.

PAN-BROILED LOIN CHOPS.

Pan broiling is a method of cooking when there is no suitable fire for broiling. For best results it should be used only for meat from which most of the fat has been removed. Loin chops which are to be pan-broiled should have the flank and most of the fat removed. After being wiped they should be put into a very hot frying pan and should be turned frequently. If a skillet or griddle is used, do not allow the chops to fry in grease; the pan should be greased enough to prevent sticking but no more. The pan should be very hot at first, and the chops are to be kept moving in order to prevent sticking. In order to avoid piercing the chops in turning them, they should be grasped between two forks or with a knife and fork. The time of cooking depends, of course, upon the thickness of the chops and whether they are desired well done or not. From 6 to 10 minutes is the usual time. Pressing the chop against the side of the frying pan helps to complete the cooking. Pan-broiled chops may be served plain or with savory, tomato, or onion sauce.

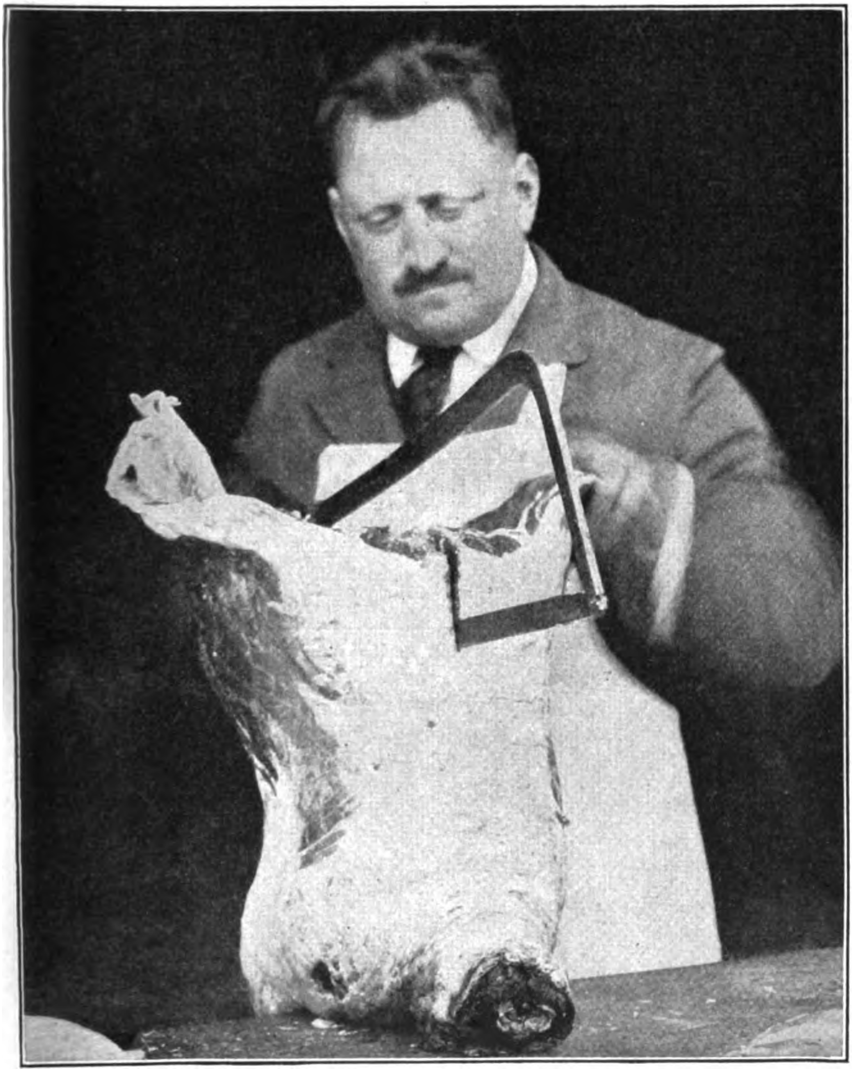

FIG. 23.—Dividing the fore part.

SAVORY SAUCE.

To the fat in the pan in which the chops have been broiled, add butter enough to make about 2 tablespoons. In this, brown 3 tablespoons of flour and add 1 cup of water or stock. Season with salt and pepper and add one-half onion, finely chopped, and 1 tablespoon each of capers and finely chopped pickle.

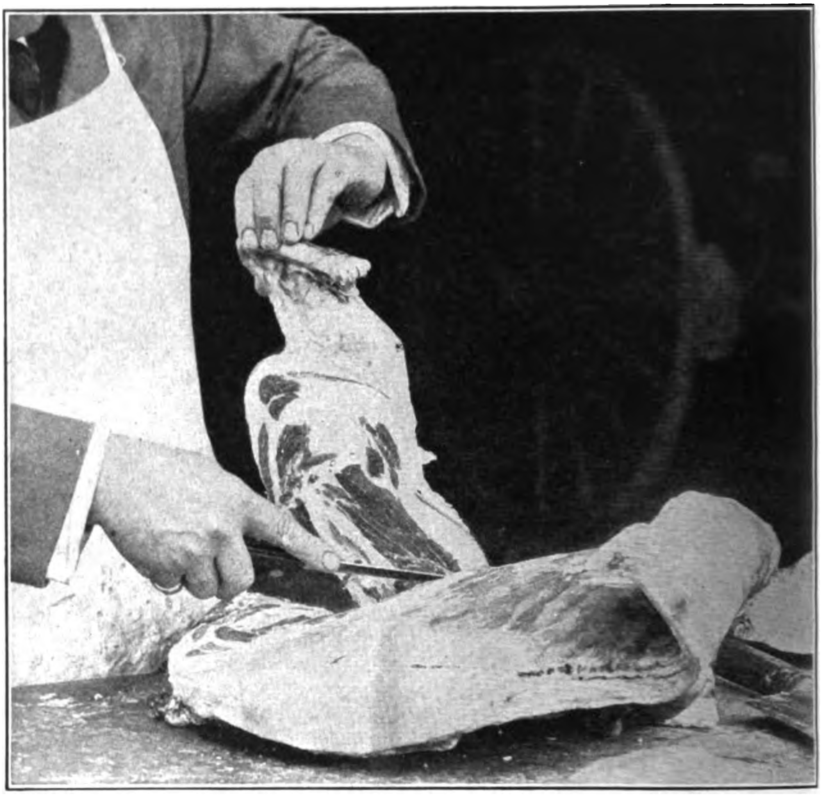

FIG. 24.—Removing shoulder from fore quarter of mutton.

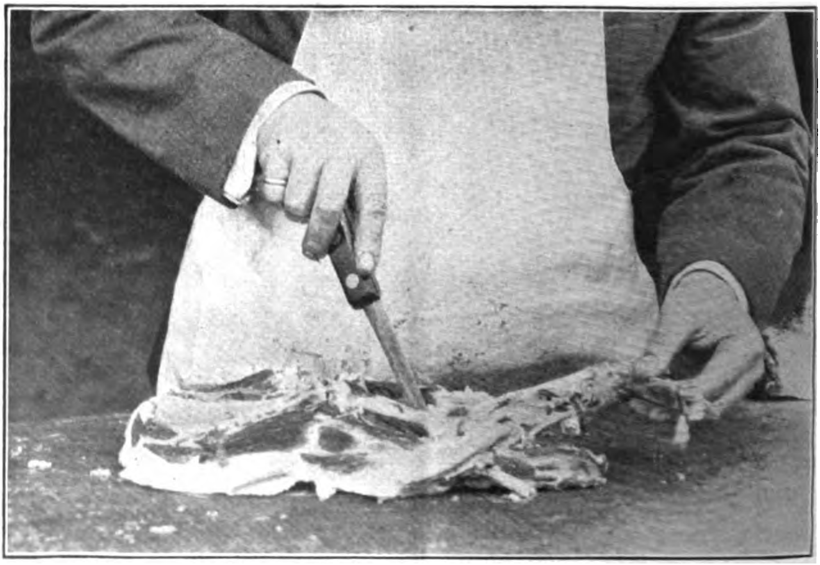

FIG. 25.—Removing bones from mutton shoulder.

TOMATO SAUCE.

2 tablespoons butter.
2 tablespoons flour.
Stewed or fresh tomato enough to make 1 cup when well boiled down.
1 stalk celery.
1 sliced onion.
Few cloves.
Salt and pepper.

Cook the tomatoes with the seasonings. Cook the flour thoroughly in the butter, strain the tomatoes, and add to them the butter and flour. Cook all together until smooth, stirring constantly.

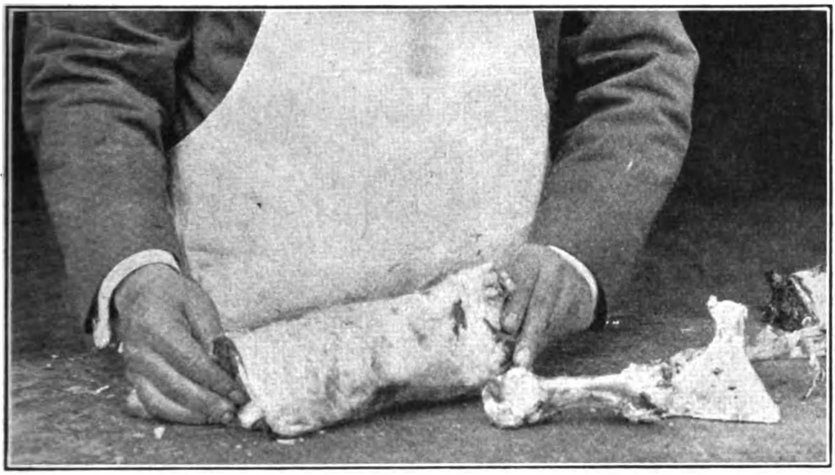

FIG. 26.—Mutton shoulder with bones removed.

LEFT-OVER MUTTON AND LAMB.

MINCED LAMB.

Chop pieces of cold roast lamb fine. It is good served with potatoes or on toast. A pint of chopped meat will serve a family of five or six. Rub 1 tablespoon each of butter and flour together; add ½ pint of milk, stir until boiling; add tablespoon of finely chopped parsley, ½ teaspoon of salt, and a dash of cayenne. Add the meat and stand over hot water until served. If served on toast trim the toast and butter and cover with a thick layer of the mince, making a little hollow in the center. Into this hollow (if you have plenty of eggs and want a heartier dish) put a poached egg. Six will be required for this quantity of meat.

CUTLETS OF COLD MUTTON.

From a leg of mutton which has been cooked rare, cut pieces about the size of an ordinary loin chop. These may be fried in a little fat, or egged, crumbed, and fried in deep fat, or they may be brushed over with fat and broiled. The result is more like meat cooked for the first time than the ordinary warmed-over meat. Cutlets so prepared may be served with any of the sauces suggested for serving with chops.

STEAMED MUTTON AND RICE.

4 cups cooked, or 1 cup raw rice.
2 cups cooked mutton cut into small pieces.
1 teaspoon salt.
¼ teaspoon pepper.
Few drops onion juice.
1 tablespoon chopped parsley.
¼ cup bread crumbs.
1 egg.
Stock or water.

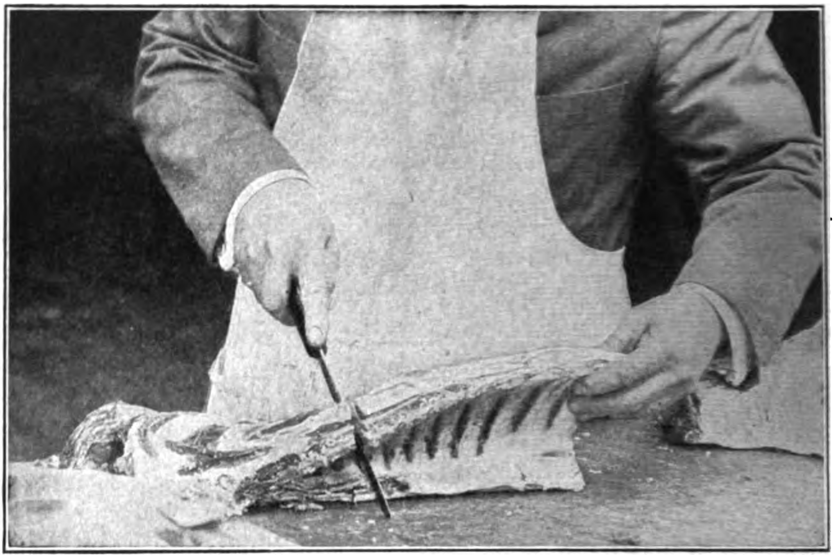

Fig. 27.—Removing rack or rib cut.

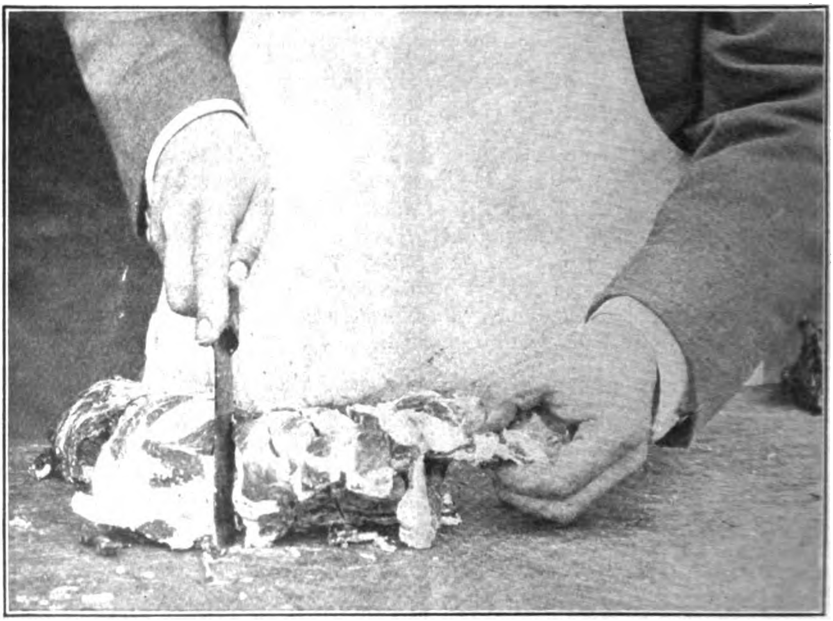

Fig. 28.—Cutting shoulder chops.

Grease a mold or bowl of about 1½ quarts' capacity and line with cooked rice. Heat the meat with the other ingredients, using stock enough to make a mixture that is moist but will hold its shape. Pack the meat in the center of the mold and cover with the remaining rice, grease the cover of the mold (if a bowl is used, a plate will serve for a cover), steam or cook in water enough partly to cover the mold until the contents are thoroughly heated through. Turn it on a hot platter and serve with tomato sauce.

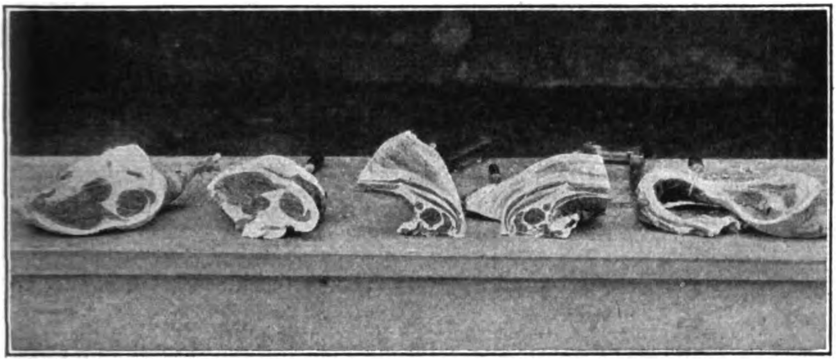

FIG. 29.—Cuts of lamb carcass.

This recipe, it will be noted, suggests the use of bread crumbs instead of flour for thickening, which is often a way of saving bread that might otherwise be wasted; it is also one way of obtaining variety as a different texture results from that when flour is used.

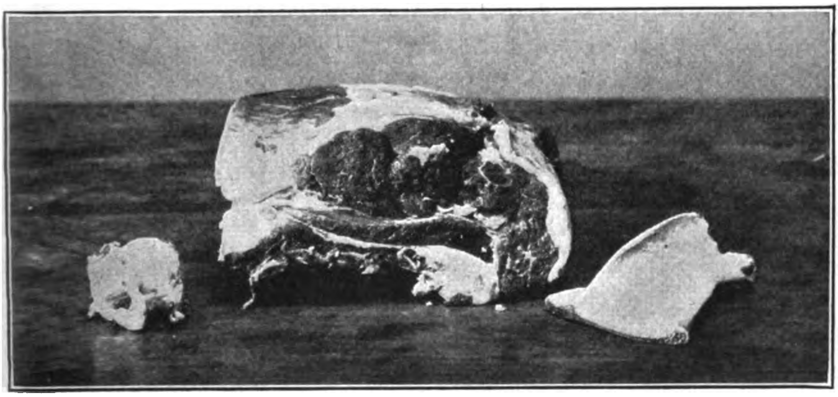

FIG. 30.—Lamb's shoulder with bones removed.

CORNED MUTTON AND ITS USES.

The shoulder is the cut most frequently corned. The leg is delicious corned, but is too expensive to be used in this way except for the purpose of preserving what would otherwise go to waste.

10 pounds mutton.
1½ cups salt.
½ tablespoon baking soda.
1 tablespoon saltpeter.
¾ cup brown sugar.

Rub the salt thoroughly into the meat, covering every portion, and allow to stand with the salt on it for 24 hours; then pour over it the other ingredients dissolved in a small quantity of lukewarm water. Add water enough to cover the meat and allow it to stand in the brine for at least 3 or 4 days. Meat thus corned will keep in good condition for a long time. Since mutton absorbs salt more readily than beef, special care should be taken to avoid using too much of it.

Corned mutton may be used in all the ways in which corned beef is used. The broth in which it is boiled makes good soup when seasoned with onion and turnip or other vegetables.

MUTTON SAUSAGE.

Sausage can be made from mutton mixed with pork in much the same way as beef is used for similar purposes. A general formula is: Mutton, 2 parts; lean, fresh pork, 1 part; and fat pork, 1 part; salt and seasoning to suit the taste. Such sausage can be made into cakes and cooked at once or may be packed in skins or bags in the usual way. Homemade sausage is very commonly kept frozen. When this is not possible, it is often convenient to make small quantities for immediate use.

MUTTON SAUSAGE.

1 pound mutton free from bone.
½ pound fat fresh pork.
⅛ teaspoon black pepper.
½ teaspoon salt.
¼ teaspoon each marjoram, thyme, and sage.

Put the meat through a meat or sausage grinder and mix thoroughly with the other ingredients. Pack in a bag about 2½ inches in diameter and keep in a very cool place. Cut into slices and fry. If it is to be used at once packing in a bag is not necessary; instead the chopped and seasoned meat may be made into cakes.

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FARMERS' BULLETIN 1173

UNITED STATES DEPARTMENT OF AGRICULTURE

PLANS OF RURAL COMMUNITY BUILDINGS

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A HOME without a house is possible but in no sense desirable, for a good house adds to a home a quality of "hominess" which nothing else can supply. In somewhat the same way, and under somewhat the same difficulties, a community can get along without a community house. A community can "live around" from church building to church building, from school building to school building, from hall to hall, and never experience the distinct pleasure of occupying a community house.

However, a good community house adds something to community life. The community idea, indeed, the very conception of "communityness," so to speak, pervades the mind of the community when it enjoys the use of a community building of its very own.

The community building movement enters the farming situation at a time most opportune. The social and economic life on farm, in farm neighborhood, and in village and small agricultural city is being organized on a community basis; and the great demand in connection with this social and economic development is for an adequate building program, good housing facilities, and expressive architecture. The country-life movement, moreover, which sums up modern thought on the life side of the farm, is a community movement in large part and will welcome the community house as a tangible symbol of rural social unity. And the development of the Farm Bureau, which sums up modern hope on the economic side of the farm, is at bottom a matter of community organization which will find a community home in a community house.

C. J. GALPIN.

Contribution from the Office of Farm Management and Farm Economics
H. C. TAYLOR, Chief
Washington, D. C. January, 1921

PLANS OF RURAL COMMUNITY BUILDINGS.

W. C. NASON, *Assistant in Rural Organization, under the Direction of* C. J. GALPIN, *Economist.*

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THE growing popularity of the practice of erecting separate buildings for rural social-center work makes the question of plans for such buildings one of immediate interest. Department Bulletin 825, "Rural Community Buildings in the United States," treats of the general nature of community buildings, being illustrated by a few specific examples. In the following pages are presented the floor plans of a wide variety of community buildings now in actual use.

Before a community decides the question of erecting a building it should make a thorough study of the local situation. The study

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NOTE.—Acknowledgment is due to the Bureau of Public Roads for valuable assistance rendered in the preparation of this bulletin.

should show that an actual need for a building is felt by the various organizations of a public nature and by the people themselves. It should demonstrate that the building can and should be maintained as a permanent institution.

After it has been decided to erect a building, numerous questions arise.

TYPE OF BUILDING.

The original study should not only determine the need of a community building but also the most desirable type. No two communities are alike, and each will desire to put up its own particular kind of building, just as every person builds his own type of house.

The size and type of the building depend upon the population of the community, the amount of money available, maintenance expenses, the uses to which it is to be put, future needs, and similar factors.

Population.—The building should be large enough to serve the present needs of every member of the community and every organization, regardless of party, creed, or class, no matter how far distant they may be, and should be located at a place naturally frequented by all members of the community.

Future needs.—If it does not seem practicable to provide in the beginning for future growth, the building should be so constructed that additions or other stories could later be constructed without detracting unnecessarily from the symmetry of the structure or the adequacy of the room arrangements.

Money available.—The amount of money that can be secured from a given community for a building can not be accurately estimated in advance. There may be two conflicting tendencies. One will come from the enthusiastic backers of the enterprise, who will fix an estimate higher than can be reached. The other will originate with those members of the community who are doubtful as to the success of movements for the common betterment or frugal in financing such enterprises. A middle course between these two extremes should be the aim.

Before an attempt is made to estimate the funds available, however, a well-directed campaign of enlightenment should be carried on throughout the surrounding country, with the object of making generally known the benefits to be derived from the erection of the building.

Maintenance expenses.—Before the size of the building is finally decided upon it should be made certain through careful study and an estimate of probable receipts and expenditures that the building can be permanently maintained.

Uses.—Every community will have its own particular uses for a building, and these can be determined only by the people themselves. It may be stated, however, that a standard community building should have as a minimum these accommodations:

1. An assembly room, perhaps with movable seats, that can be used as a meeting place for the people or for various organizations. With the seats removed the room will be available as a gymnasium, as a game room, as a dining room, or for fairs and exhibits.
2. A stage on which lectures, plays, and various entertainments can be given and which may have a screen for motion pictures.
3. A kitchen where food may be prepared.
4. A place where lunches, suppers, and banquets may be served.

The more advanced communities would need other accommodations. These should be carefully estimated in determining the size of the structure. Future growth should be taken into consideration.

ARCHITECTURE.

Permanency.—The type having been definitely decided upon, proper attention should be given to the advisability of building for the future. A permanent structure of durable materials is cheaper in the end than a temporary structure of light materials. Location, climate, and available building materials must be considered.

Serviceability.—Considerable initial expense and much time and energy in the future will be saved by carefully planning the arrangement of the different rooms, corridors, stairways, doors, kitchen conveniences, and toilet comforts. If expense is the chief consideration, much money may be saved by having one large room, with movable furniture, serve as an assembly hall, gymnasium, dance hall, and dining room. Service windows, swinging doors, or food elevators between dining room and kitchen make for convenience. Wide, gradually sloping stairways, numerous exits, outswinging doors, and assembly rooms confined to the first floor make for safety. A room arrangement facilitating proper supervision is both economic and convenient. Large folding doors sometimes make it possible to throw the whole floor into one large room. In the kitchen many steps can be saved by an economic arrangement of sink, cupboards, stoves, serving tables, etc. Much can be added to the utility of a building by attention to the proper rules for ventilation, heating, lighting, acoustics, and water supply. The serviceability of the building should apply to the needs of women as well as those of men, equal accommodations and conveniences being supplied.

Harmony.—An attempt should be made to have the design of the building harmonize with the designs of other public buildings in the community. In sections of the country where there are no existing architectural standards or traditions an opportunity is afforded for initiating an approved type of architecture which may serve as an example for future buildings.

Design.—While serviceability should be, perhaps, the main consideration, beauty should in no wise be neglected. As the building is to be the center of expression of various arts, such as music and the drama, so the structure itself should be an example of good taste, dignified, pleasing to the eye, and appropriate. Overornateness, elaboration, and display should, however, be avoided.

THE SITE.

Location is second in importance only to the character of the building itself. No matter how architecturally pleasing a building may be, its effect is lost if it does not have the proper setting. Ugly or bare surroundings should be avoided. Nor should the building be obscured by taller structures closely surrounding it. It should be conveniently located with reference to those who would use the building most, bearing in mind the relative importance of the uses to which it may be put, and should be easy of access by road, car line, and other ways of approach. Incidentally, a generous site near the center of the neighborhood possesses other advantages not pertaining to the subject of this bulletin.

CONSTRUCTION.

The best is the cheapest in the end. The work should be in charge of a competent contractor, who should carefully follow specifications. Even in the case of a building constructed by voluntary labor, much time and valuable materials may be saved by expert supervision. Such work as the erection of the stage, the location of the auditorium, the construction of the bowling alleys and the swimming pool, proper heating, lighting, and ventilation, requires expert direction.

BUILDING COSTS.

It is quite impossible to give adequate estimates of the cost of erection of any particular building, the plan of which is shown in this bulletin. These costs are in no sense fixed, but are modified by such considerations as location, time of erection, climatic influences, amount of free labor available, availability of cheap building materials, fluctuating commodity prices, changing markets, etc. A reputable archietct has estimated that a building which before the war cost $2,500 would in 1919 cost $3,747. Average increase of labor costs is estimated at 33 per cent, that of material 64 per cent, or an average of both of about 50 per cent.

TYPES OF BUILDINGS FOR WHICH PLANS ARE PRESENTED.

The plans presented in the following pages are those of actual buildings in successful operation. The houses are located in various parts of the country under different climatic conditions. They are of many different types, since each community has a certain object in mind and needs a building to meet specific conditions. The builder of a dwelling house often finds, after the house has been used, that it has certain defects that can later be corrected. Similarly, some of these communities, through use, have found that certain changes might improve their buildings. In a general way, however, they have proved admirably adapted to the purposes for which they were erected. It is hoped that those contemplating the erection of a community house may find, among the various plans presented, some that will be helpful to them in making a choice of plan, or perhaps complete plans that, with a few changes, either in appearance or with regard to convenience, may be adapted to the needs of the community. Such changes will usually be found desirable to meet local conditions or to keep abreast of improvement in design or equipment.

Classification.—In order to show the kinds of communities which have erected the various types of buildings, the communities are classified under the heads (1) Farming Community, (2) Farming and Village Community, (3) Farming and Town Community, and (4) Farming and Small City Community.

Under the first head are classed those buildings financed, controlled, or used by a community the industry of which is largely farming. Buildings in a village and supported by farming and village people are placed under the head, "Farming and Village." "Farming and Town" buildings are those in a group larger than a village, but still having large farming use and control. A building in which farmers have a very considerable interest, but which is also largely participated in by the people of a small city is classified as, "Farming and City."

FARMING COMMUNITY.

IMPROVEMENT CLUBHOUSE FEATURES.

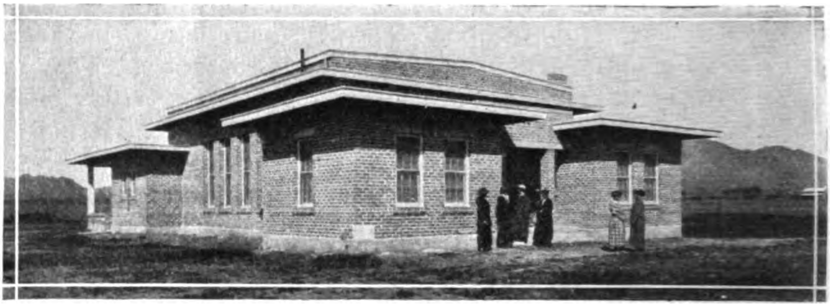


FIG. 1.—Community house, Madison (Phoenix R. F. D.), Ariz.

A standard community house located six miles from a town, erected in 1917 by the Women's Improvement Club as a clubhouse and community center at a cost of $5,650 obtained by means of entertainments, general subscription, and a loan. One story, red brick, asbestos roof, overhanging eaves, bungalow style, suitable for warm climate.

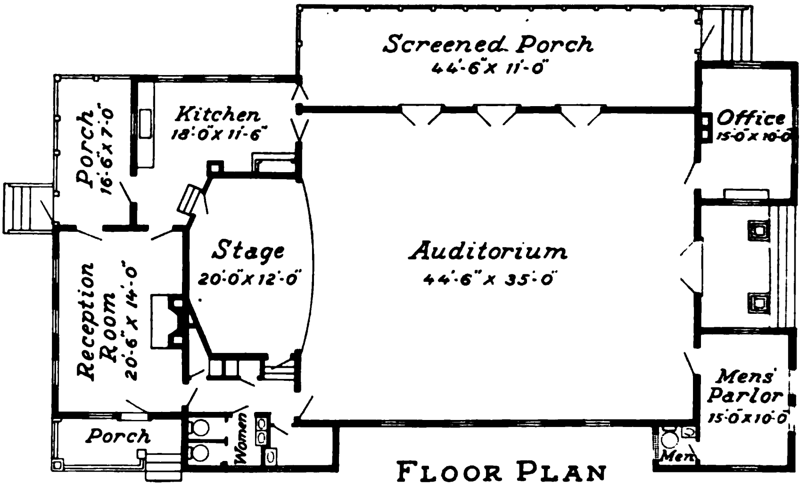


FIG. 2.—Floor plan of Madison building. (By courtesy of Burt McDonald, architect.)

TOWNSHIP-OWNED FEATURE.

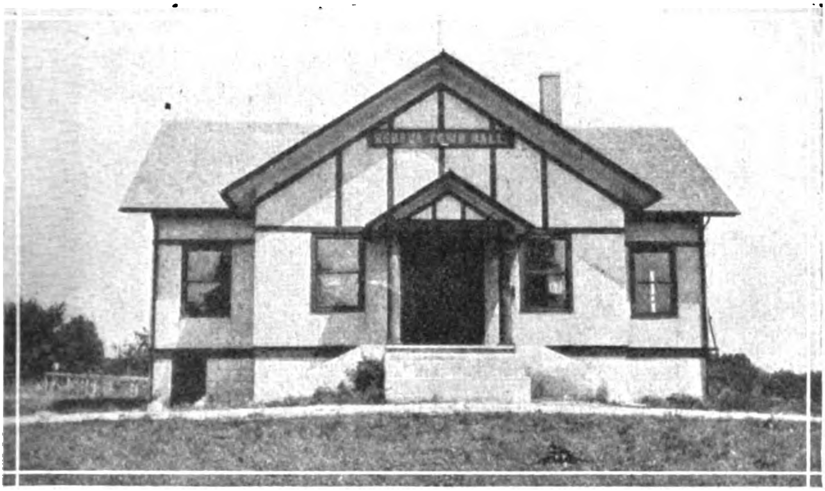
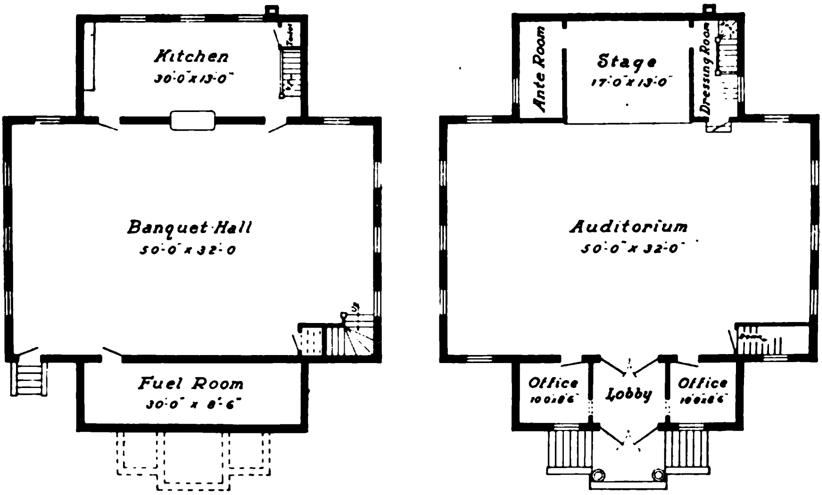


FIG. 3.—Community house at Como (Elkhorn R. F. D.), Wis.

Geneva Township building, located five miles from a town, erected in 1917 from township funds, at a cost of $5,000. The stage being located at the side of the auditorium, all the audience is within easy hearing distance. Largely used by farmers' organizations.



BASEMENT PLAN FIRST FLOOR PLAN

FIG. 4.—Plans of Como building.

GENERAL OR STANDARD COMMUNITY HOUSE FEATURES.

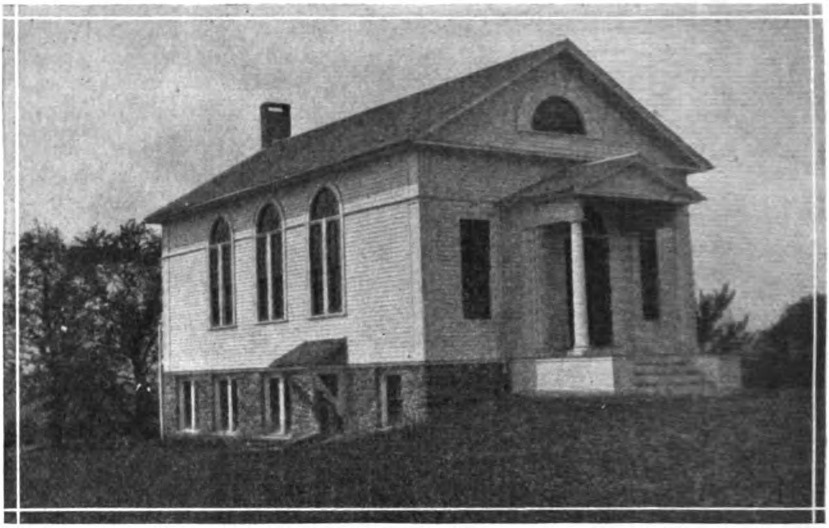


Fig. 5.—Community house at Gilead (Andover R. F. D.), Conn.

Erected in 1905 by the Hall Association through the issue of stock at $25 per share. Cost, $3,000 net. Colonial design.

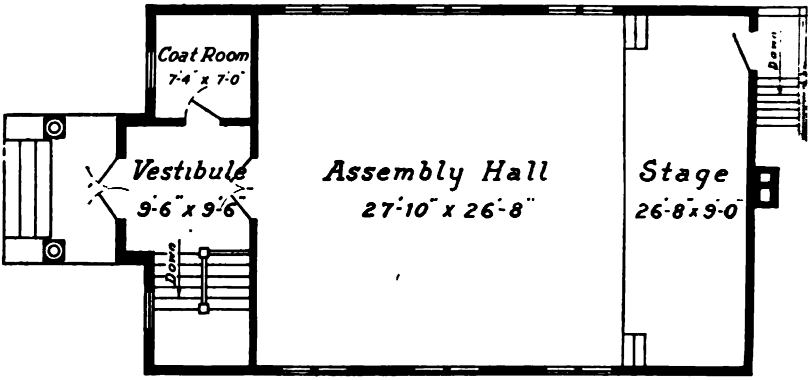


Fig. 6.—First floor plan of community house at Gilead.

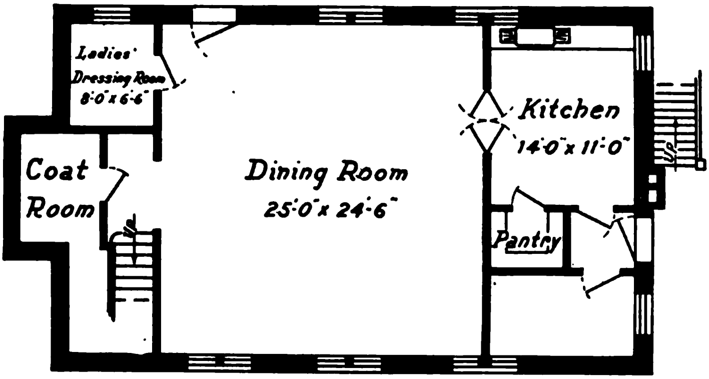

Ladies' Dressing Room 8'-0" x 6'-6"
Coat Room
Dining Room 25'-0" x 24'-6"
Kitchen 14'-0" x 11'-0"
Pantry
UP

FIG. 7.—Basement plan of community house at Gilead.

CHURCH-CONTROL FEATURE.

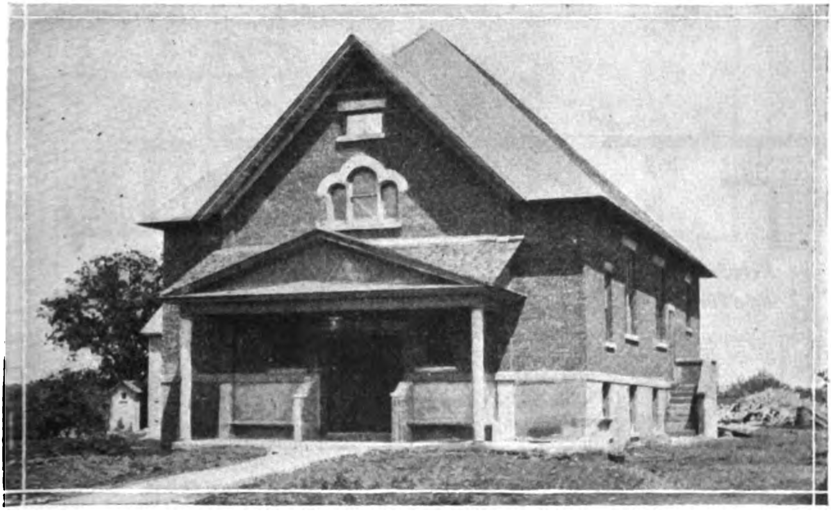


FIG. 8.—Community house at Honey Creek, Wis.

A community house with church control in a village surrounded by a large farming community, erected in 1912 at a cost of $7,000 and financed by voluntary contributions. While financed and used by the entire community, the building was placed under the control of the church so that the church business organization could be used for purposes of management and permanent control.

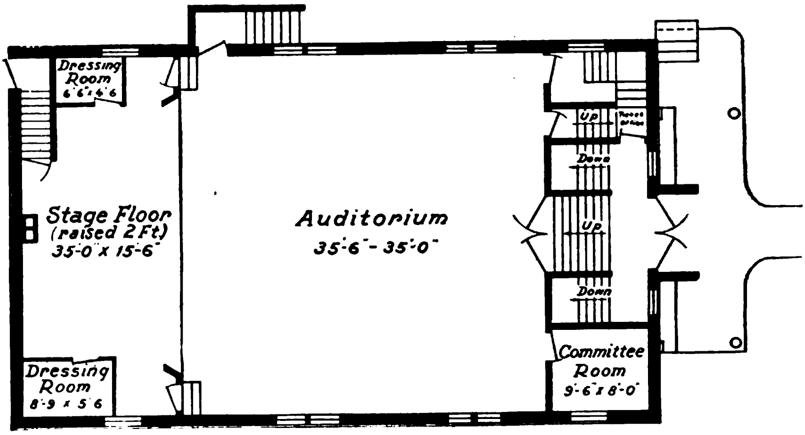

Dressing Room 6'6" x 4'6"
Stage Floor (raised 2 Ft) 35'-0" x 15'-6"
Dressing Room 8'-9" x 5'6"
Auditorium 35'-6" - 35'-0"
Up
Down
Up
Down
Committee Room 9'-6" x 8'-0"

FIG. 9.—First floor plan of community house at Honey Creek, Wis. (By courtesy of H. B. Miller, architect.)

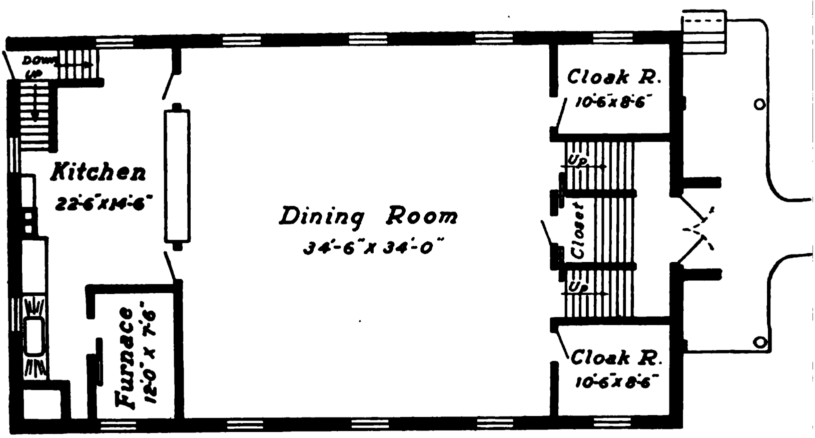


FIG. 10.—Basement plan of Honey Creek building.

FARMING AND VILLAGE COMMUNITY.

LIBRARY FEATURE.

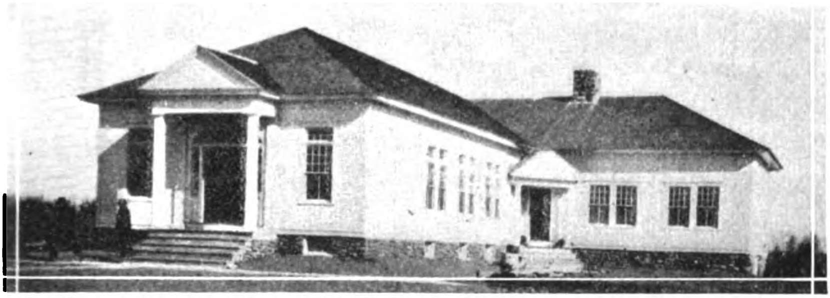
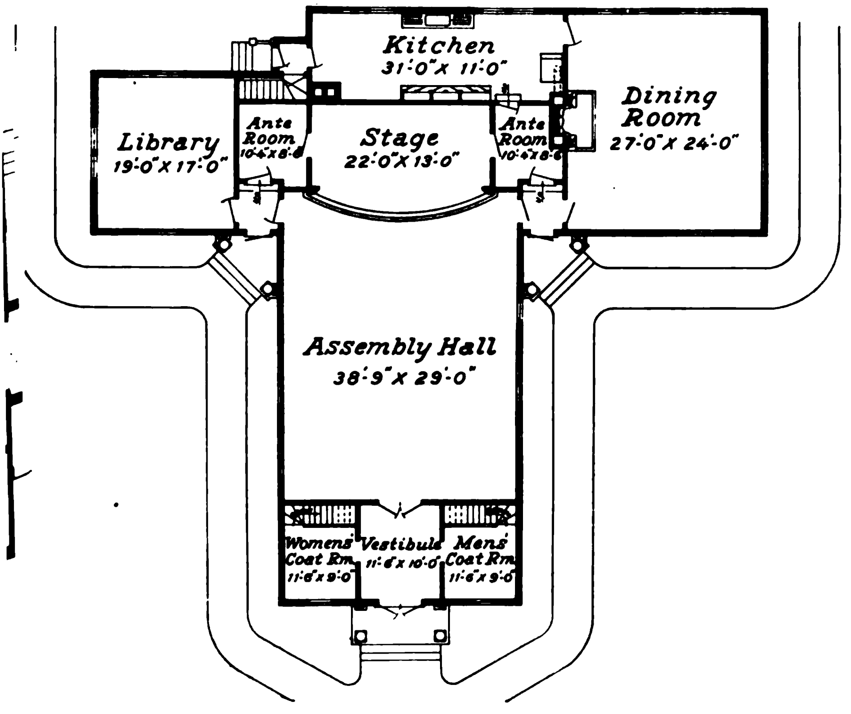


FIG. 11.—Community house at Bolton, Conn.

Erected in 1913 by Hall and Library Association, in a village of 500 population, through general contributions of money, labor, and materials. Valued then at $9,000. Colonial design, stone fireplace. Village supports the library.



G. 12.—Plan of Bolton building. (By courtesy of Whiton and McMahon, architects.)

STOCK-SHOW FEATURE.

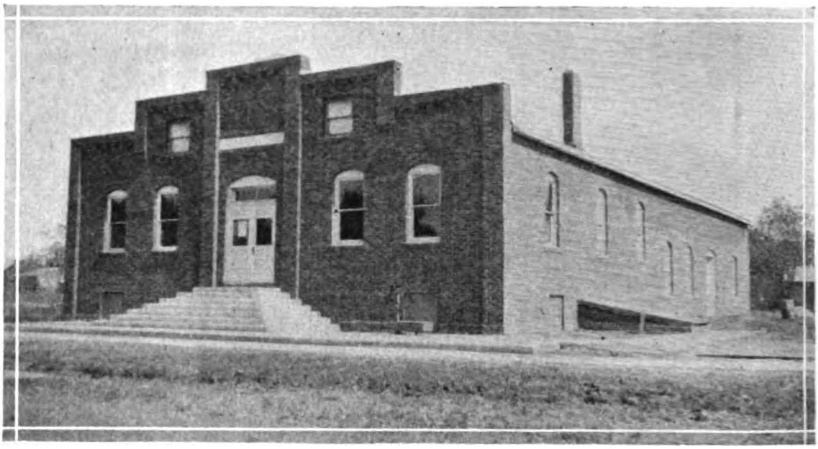


Fig. 13.—Community building at Argonia, Kans.

A township building erected in 1916 at a cost of $4,509 in a town of 500 inhabitants as the result of a bond vote made possible by special legislative enactment. Object was to unite town and country interests. A special feature is a cement strip 15 feet wide, extending between the side doors and in front of the auditorium, on which stock are brought to be judged.

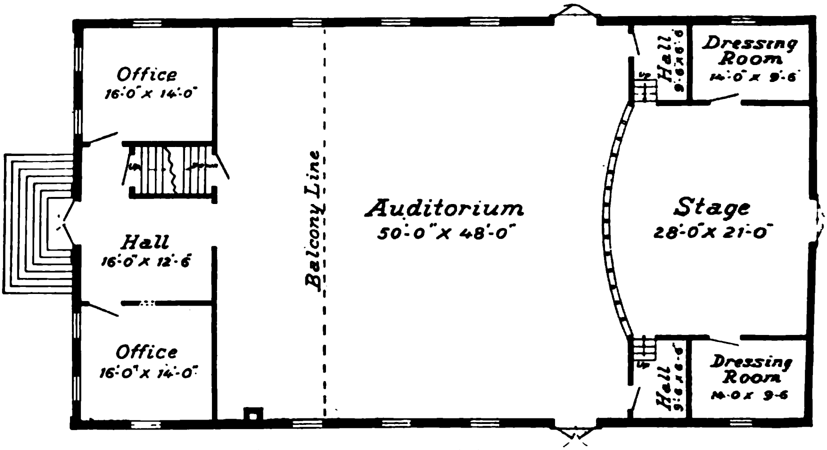


Fig. 14.—Main floor plan of Argonia building.

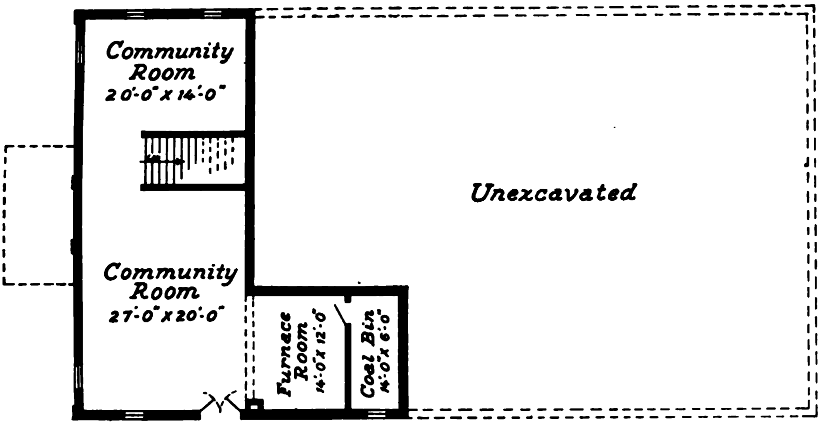

Community Room 20'-0" x 14'-0"
Community Room 27'-0" x 20'-0"
Unexcavated
Furnace Room 14'-0" x 12'-0"
Coal Bin 14'-0" x 6'-0"

FIG. 15.—Basement plan of Argonia building.

LIBRARY AND BOWLING FEATURES.

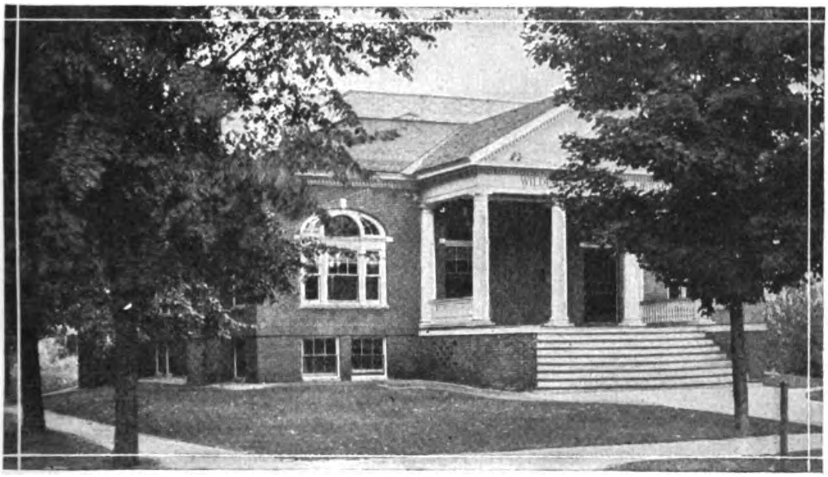
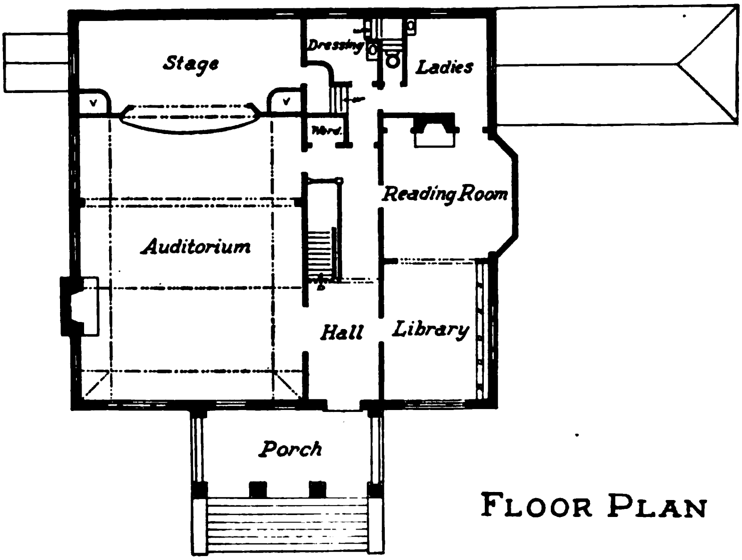
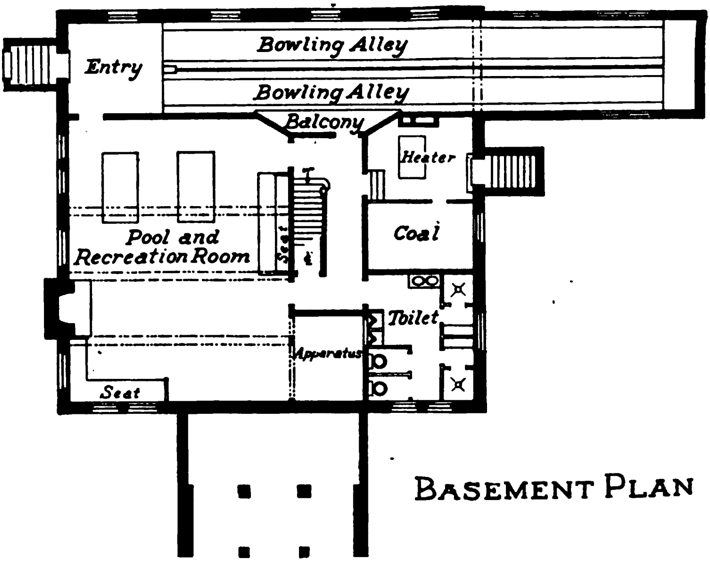


FIG. 16.—Community building at Wilder, Vt.

Erected in 1899 in a village of 300 population at a cost of $12,000 and financed by individual donation. A well-planned building, with library, bowling alleys, swimming pool, and recreation features.



FLOOR PLAN



BASEMENT PLAN

FIG. 17.—Plans of Wilder building. (By courtesy of Lewis S. Newton, architect.)

LIBRARY FEATURE.

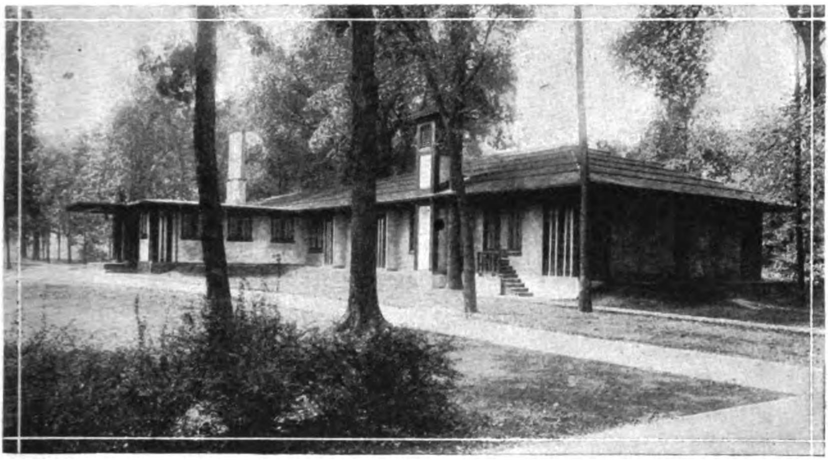


Fig. 18.—Community building at Kenilworth, Ill.

An excellent suburban type, well designed, beautifully located, and with improved surroundings. Erected in 1907 in a town of 900 population at a cost of $31,000, through the voluntary contributions of 180 people. A free circulating library is maintained for the use of all the villagers. Other features are the accordion folding doors, by means of which the floor can be separated into three distincts units or thrown into one large room, as occasion requires.

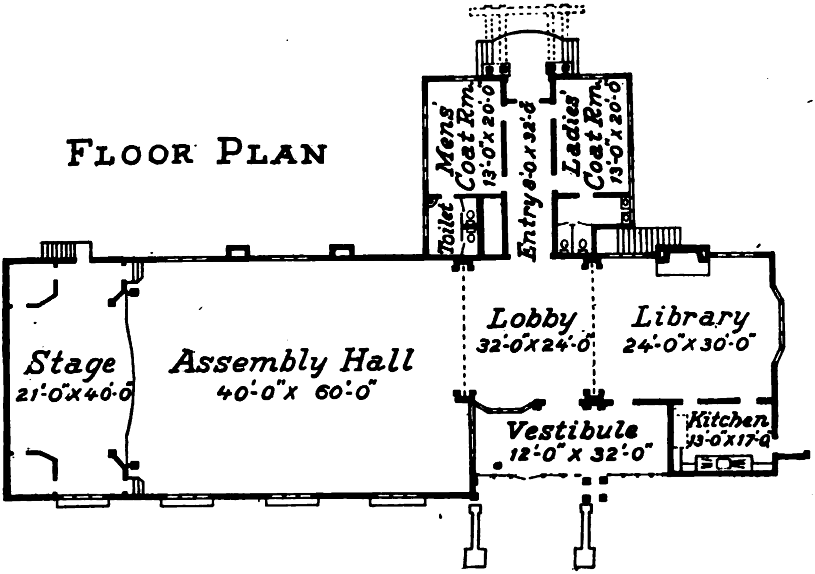

Floor Plan
Mens' Coat Rm. 13'-0"x20'-0
Entry 8'-0x32'-0
Ladies' Coat Rm. 13'-0"x20'-0
Toilet
Stage 21'-0"x40'-0
Assembly Hall 40'-0"x 60'-0"
Lobby 32'-0"x24'-0
Library 24'-0"x30'-0"
Vestibule 12'-0" x 32'-0"
Kitchen 13'-0"x17'-0

Fig. 19.—Plan of Kenilworth building. (By courtesy of Geo. W. Maher, architect.)

WAR MEMORIAL FEATURE.

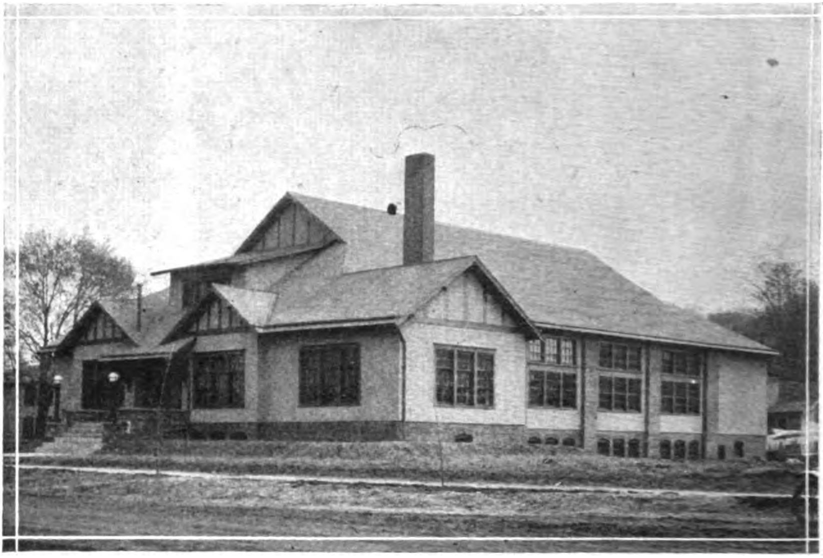


FIG. 20.—Community house at Brimfield, Ill.

Dedicated in 1919 in a village of 700 population as a memorial to the soldiers who served in the World War. A well-planned building, serving a town and country community of 2,000 people. Building unfurnished cost $26,654, and the plant was financed by the issuance of 600 shares of stock to 265 holders, one-half being farmers, and a loan of $10,000. A motion-picture machine, part of the equipment, helps maintain the building. Seating capacity of auditorium and balcony is 1,200. Building has a fireplace, two heating plants, electric and ventilating fans, air pressure tank, and electric lights.

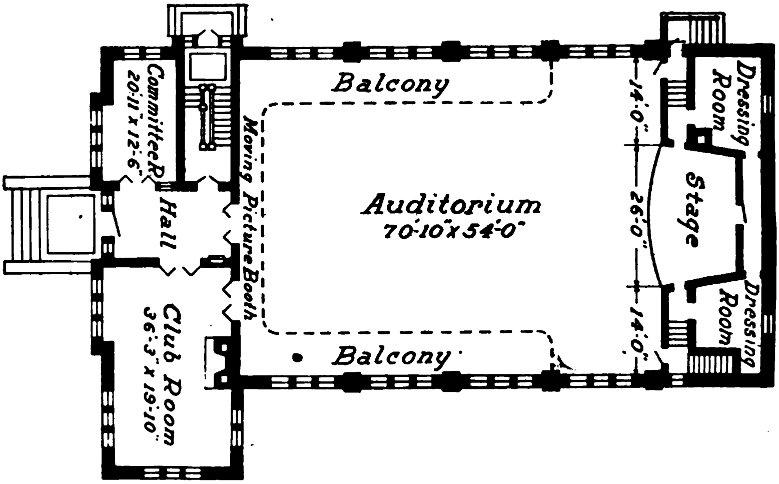


FIG. 21.—Floor plan of Brimfield building. (By courtesy of Robert J. Hotchkiss, architect.)

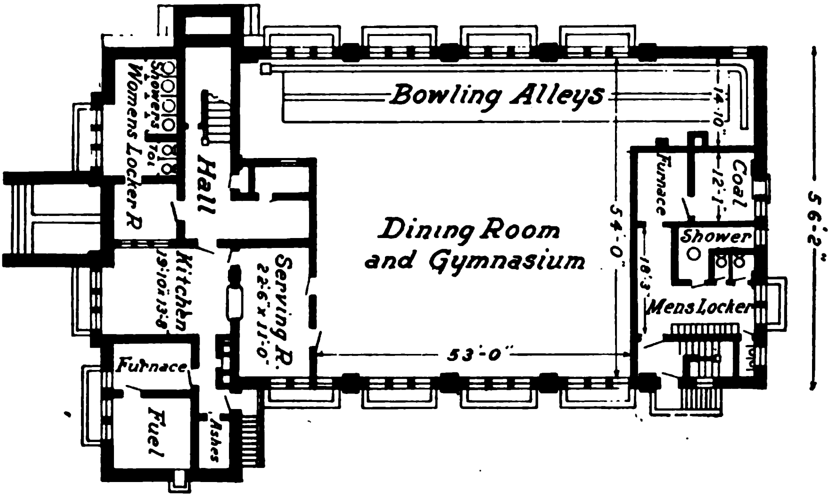


FIG. 22.—Basement plan of Brimfield building.

LIBRARY AND AUDITORIUM FEATURES.

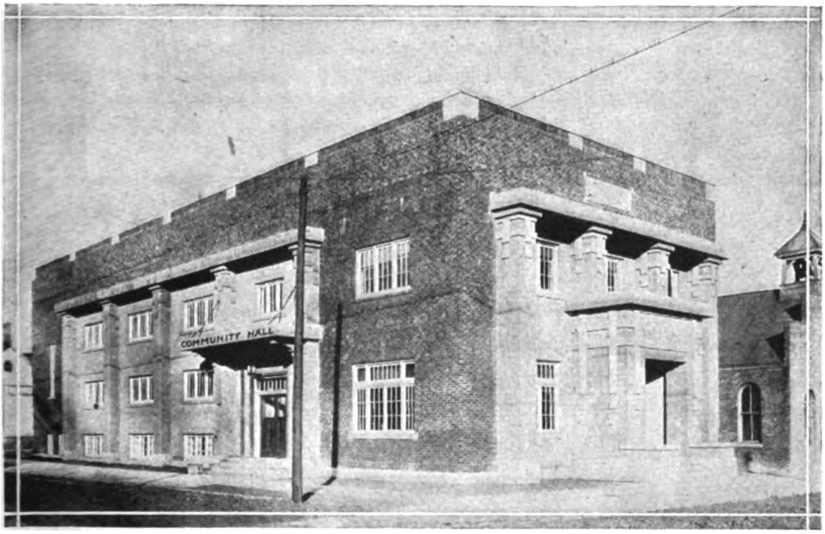
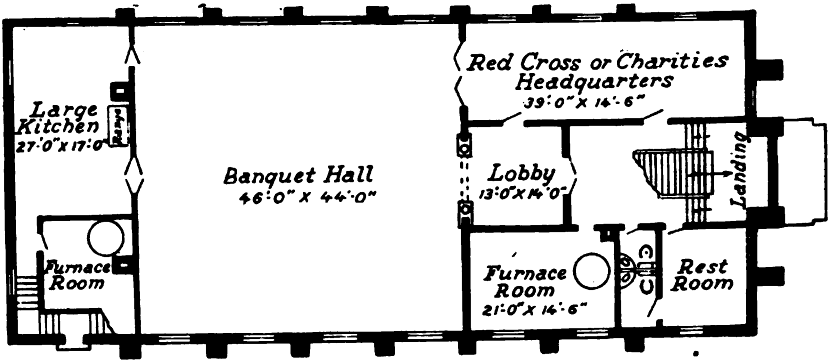
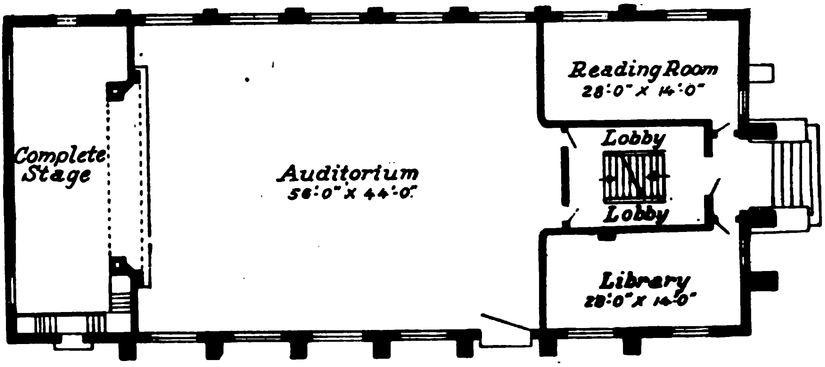


FIG. 23.—Community house at McLean, Ill.

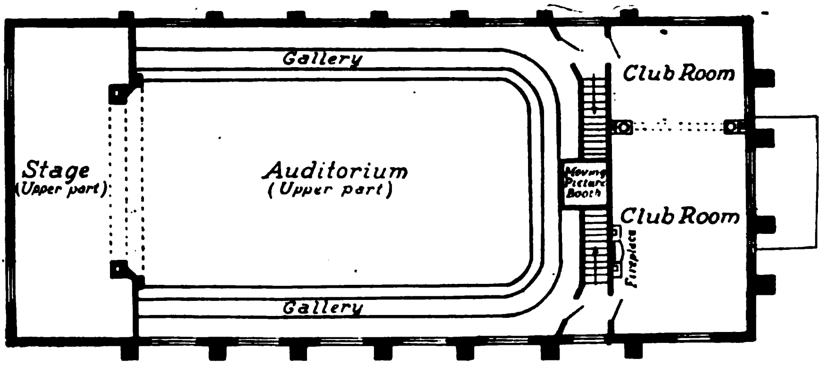
This building was erected in 1912 in a town of 700 population at a cost of $16,000 by separate hall and library associations through stock issues to 300 people, largely farmers, and a few donations. The library is separate from the hall, though the two are united by a door and have exits to separate streets. The township maintains the library and uses a room in the building for official purposes. There are two fireplaces, two heating plants, and a motion-picture booth.



BASEMENT PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

FIG. 24.—Plans of McLean building. (By courtesy of A. T. Simmons, architect.)

PLAYHOUSE FEATURE.

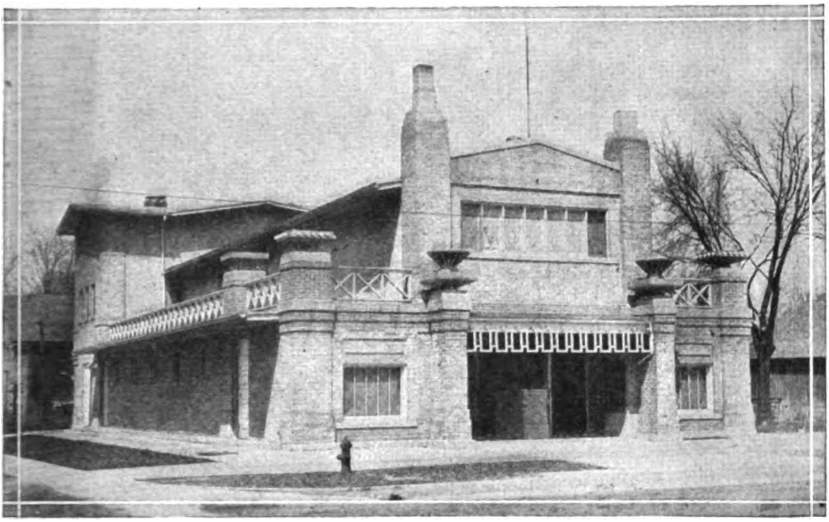


Fig. 25.—Community house at Centerville, Mich.

A community playhouse erected in a village of 600 population in 1916 with the primary purpose of encouraging town and country cooperation. Cost, $9,330, was financed by stock sales, donations, and a loan. Is equipped with a motion-picture machine. Steel trusses take the place of posts. It has slag roof, concrete floor, and an indirect lighting system. In the rear are two openings, at each side of the stage, temporarily closed, where dressing rooms are to be built later.

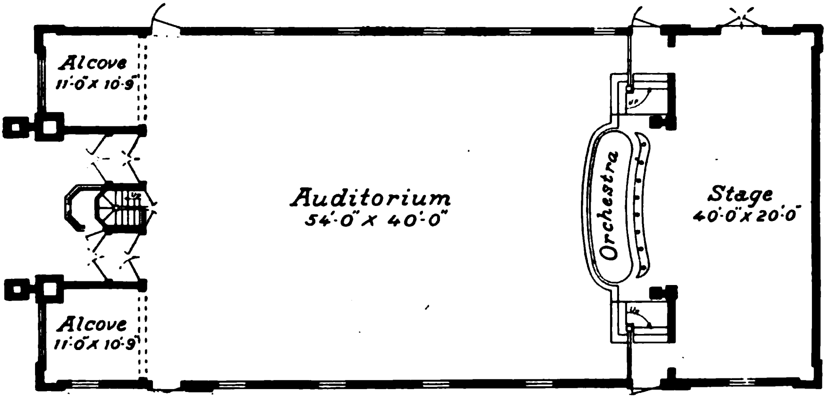


Fig. 26.—Plan of Centerville building. (By courtesy of E. O. Fullis, architect.)

FIRE-DEPARTMENT FEATURE.

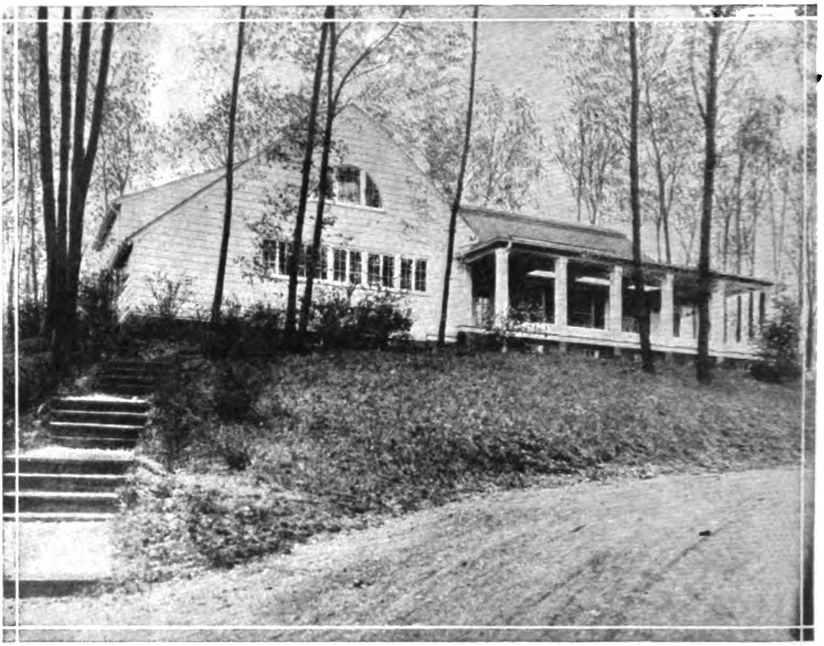


Fig. 27.—Community building at Locust Valley, N. Y.

A well-designed suburban building, erected in 1914 near a village of 500 population at a cost of $27,000, financed by contributions from 90 per cent of the families of the village and surrounding farming people, and the voluntary labor of 110 persons, all the work being done locally. A motion-picture machine has been installed, while a large room is given over to the village fire department.

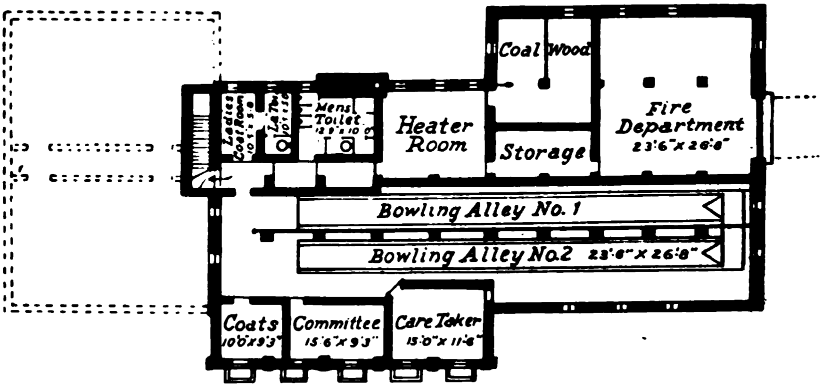


Fig. 28.—Basement plan of Locust Valley building. (By courtesy of Guy Lowell, architect.)

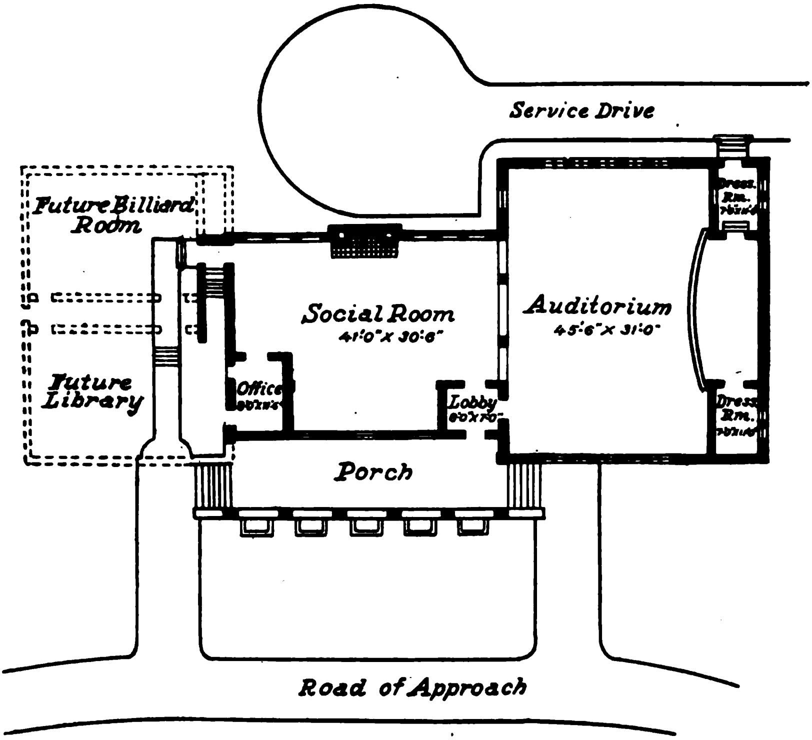


FIG. 29.—Main floor plan, Locust Valley building.

FARMING AND TOWN COMMUNITY.

AGRICULTURAL EXTENSION ASSOCIATION FEATURE.

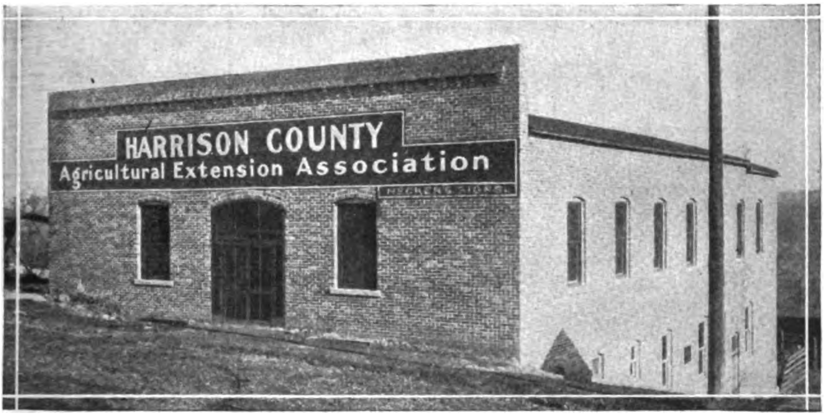
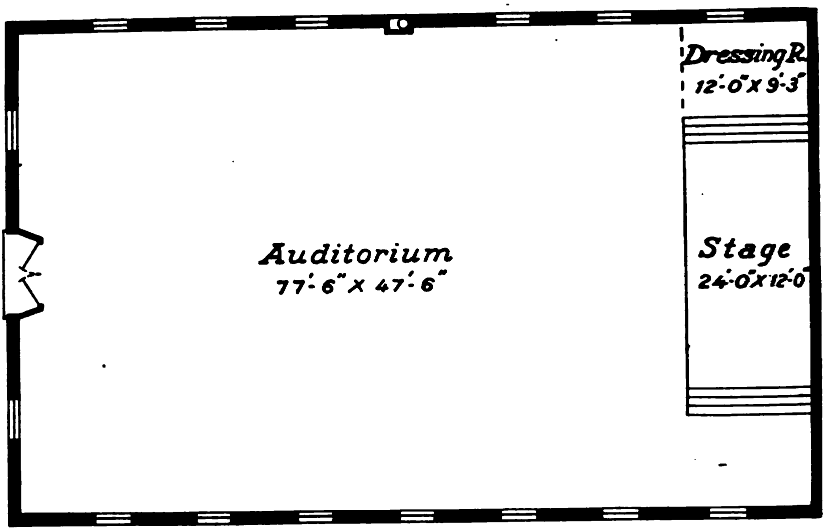
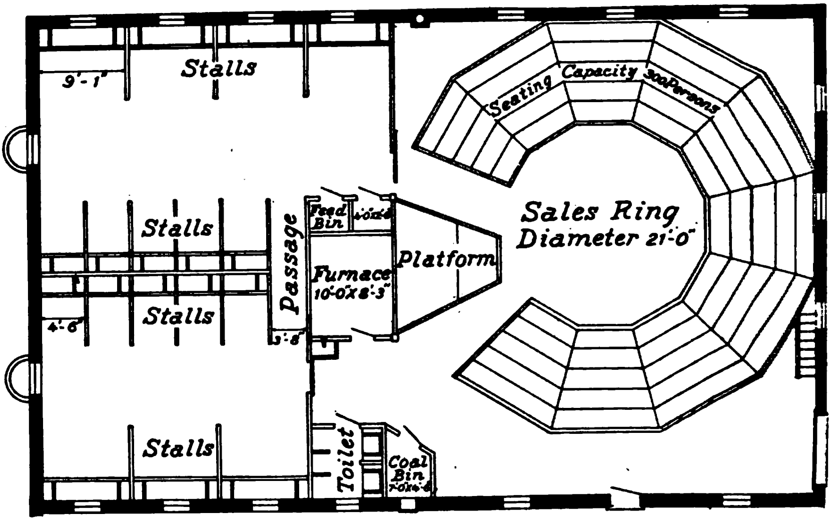


FIG. 30.—Stock show and social center building at Logan, Iowa.

The County Agricultural Extension Association erected this building in 1912, in a town of 1,400 population, as a combined stock show, agricultural exhibit, and social center, at a cost of $5,700, from stock issued to 200 holders. In the basement, for occasional use, are stalls for 80 animals, 50 wooden "horses" for corn exhibits, a sales ring with rising tiers of seats sufficient for 300 people, and a judges' platform. Above is the auditorium and stage.



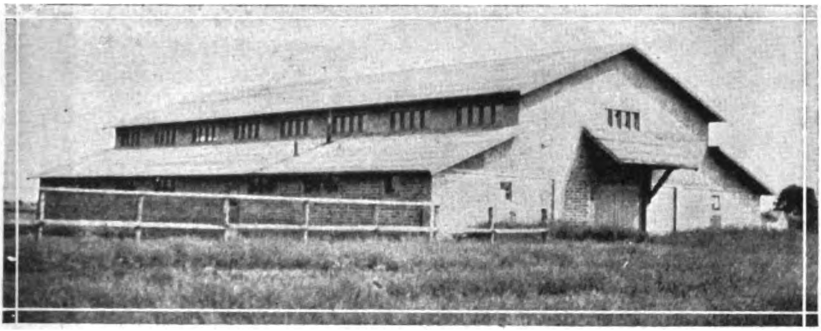
FIRST FLOOR PLAN



BASEMENT PLAN

FIG. 31.—Plans of Logan building. (By courtesy of F. W. Lanpher, architect.)

STOCK SHOW AND FALL FESTIVAL FEATURE.



· FIG. 32.—Stock show building at Stuart, Iowa.

Erected in 1914 in a town of 1,800 population by Stock Show Association (Inc.), to be used for stock sales, fall festivals, athletic contests, and to house conventions and large assemblies. It cost $5,000 and was financed by voluntary contributions. The central hard-pine floor, 72 by 48 feet, together with stage, is surrounded by a cindered space with removable bleacher seats.

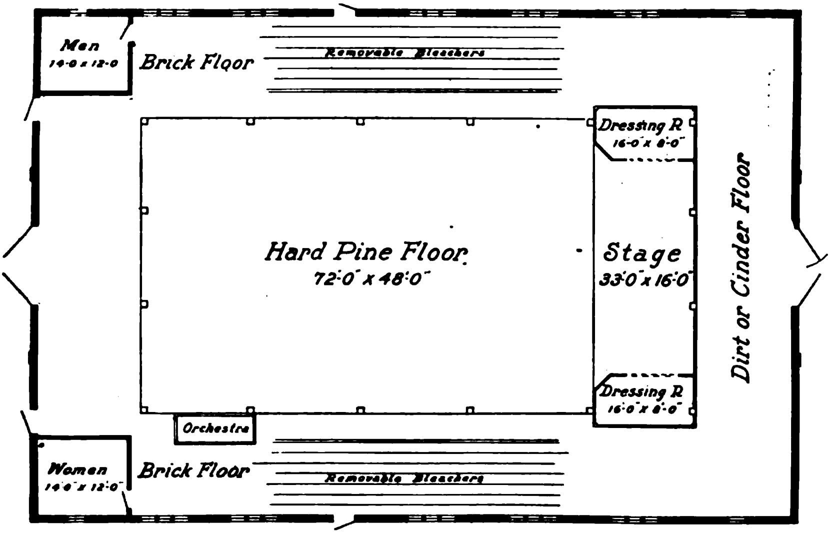


FIG. 33.—Plan of Stuart building. (By courtesy of DeJarnette & Carver, architects.)

GRANGE-HALL FEATURE.

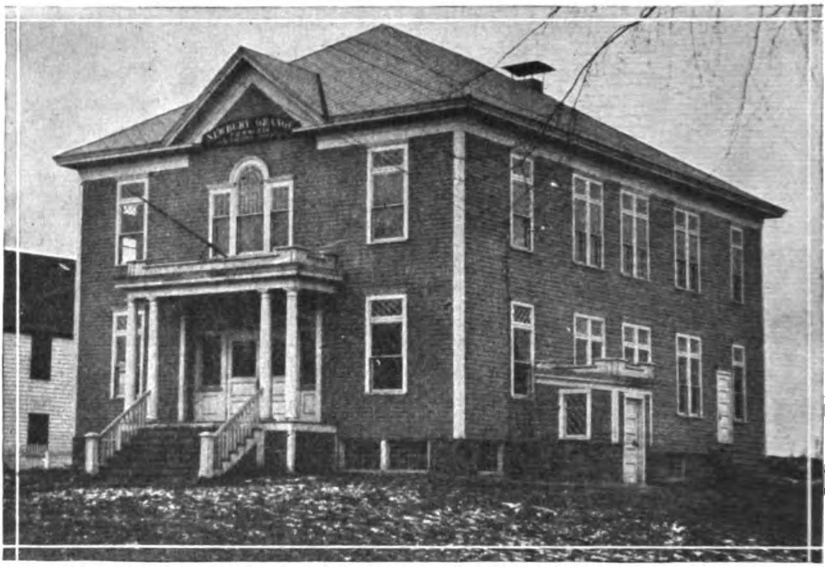


FIG. 34.—Grange Hall at Newbury, Mass.

Primarily for grange purposes, this building serves also as the community center of a town of 1,500 population and the surrounding farming community. It was erected in 1913 at a cost of $6,500, raised by the 350 members of the local grange from entertainments, sales, auctions, fairs, voluntary labor, and money contributions. Receipts from the bowling alleys and the refreshments stand help maintain the building.

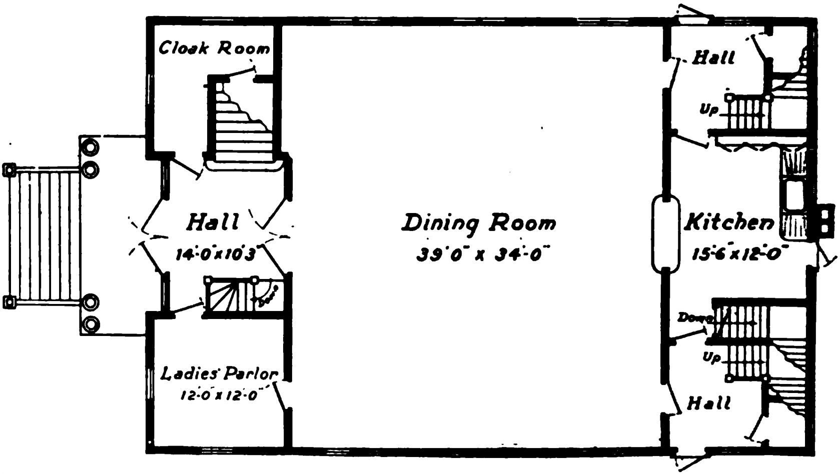


FIG. 35.—First floor plan of Newbury building. (By courtesy of I. S. Hann, architect.)

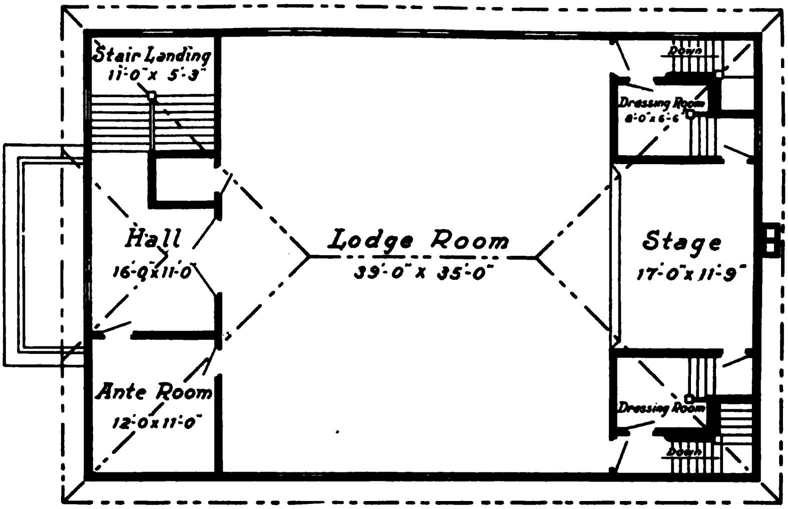


FIG. 36.—Second floor plan of Newbury building.

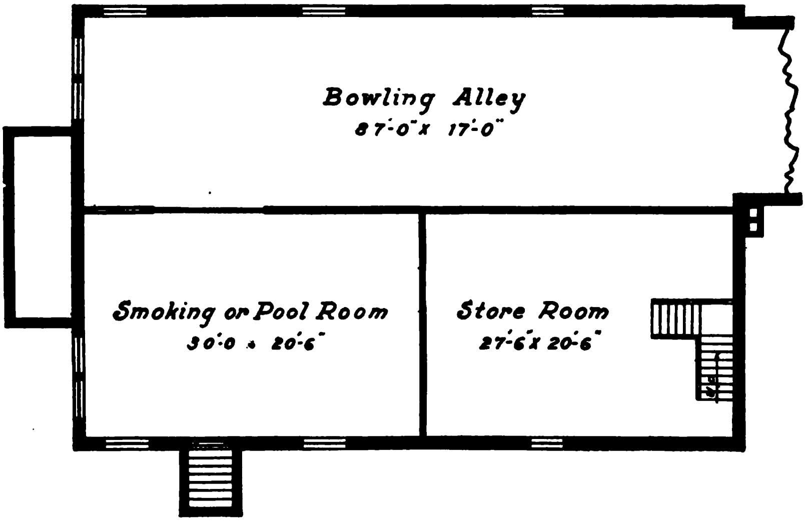


FIG. 37.—Basement plan of Newbury building.

SCHOOL FEATURE.

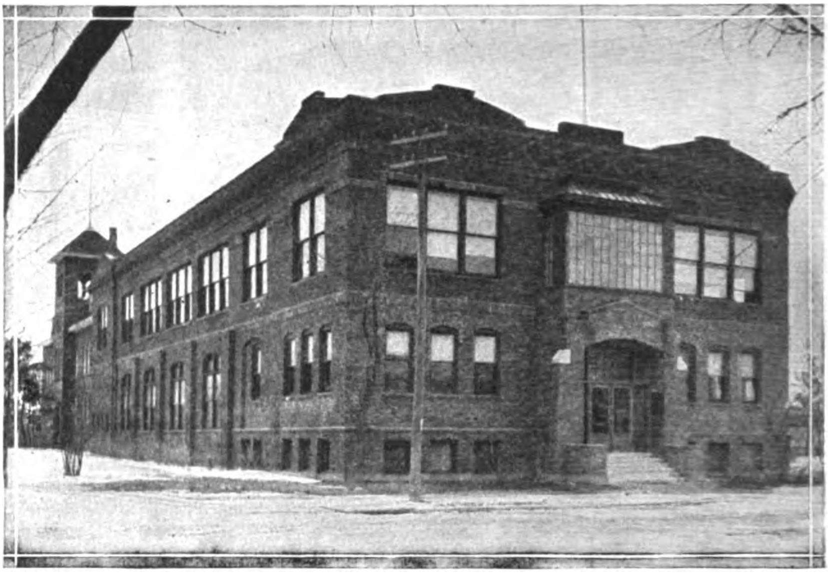


FIG. 38.—Community house at Wheaton, Minn.

A building controlled by the school district and connected with the consolidated high school. Erected in 1916 in a town of 1,300 population at a cost of $26,000, to serve the town and surrounding farming community. Financed by means of bond sales, entertainments, general contributions, etc. It houses the industrial department of the high school, the county farm bureau, annual agricultural exhibit, a community theater, a ladies' rest room, and a library.

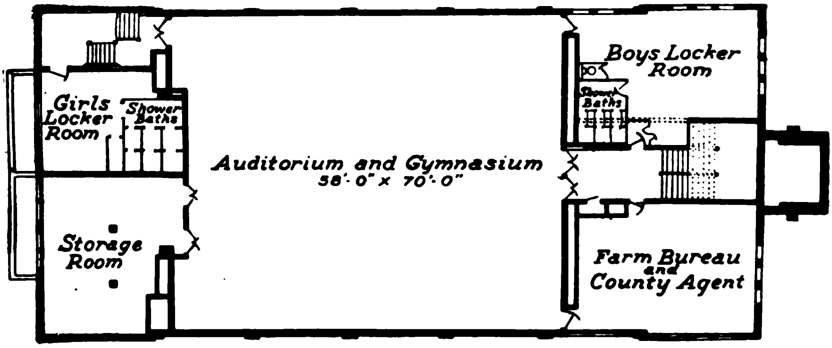


FIG. 39.—First floor plan, Wheaton building.

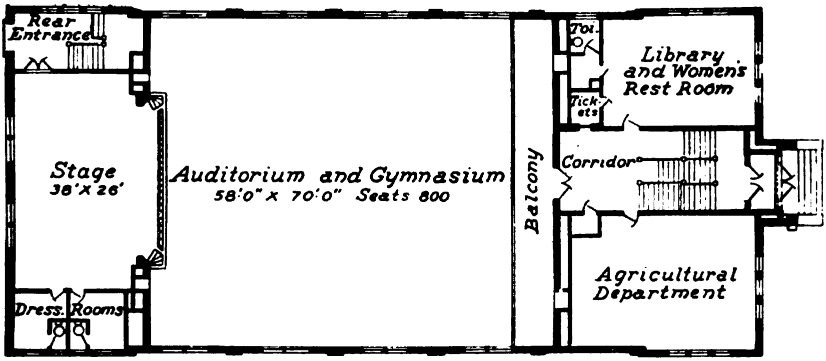


FIG. 40.—Second floor plan, Wheaton building.

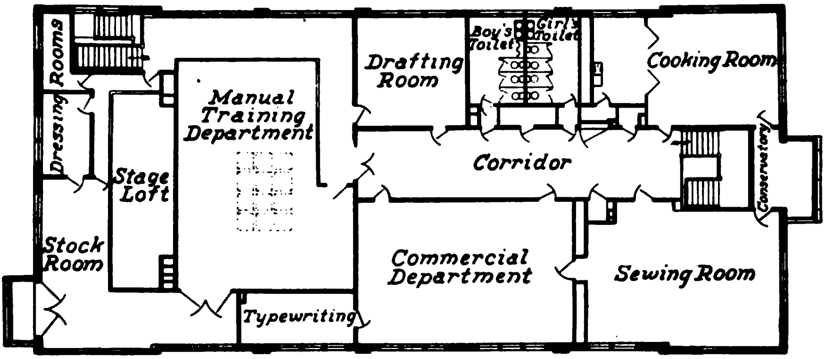


FIG. 41.—Third floor plan, Wheaton building.

SWIMMING POOL AND RUNNING TRACK FEATURES.

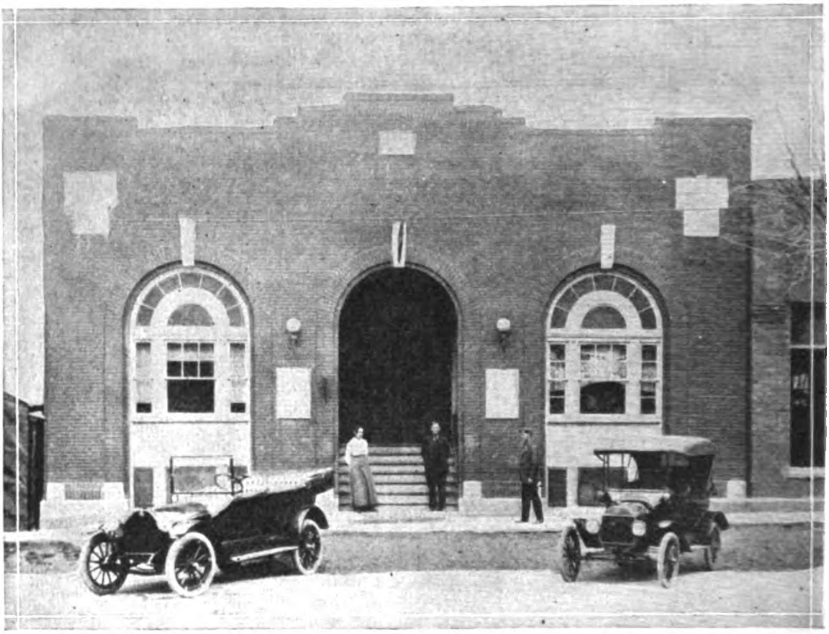
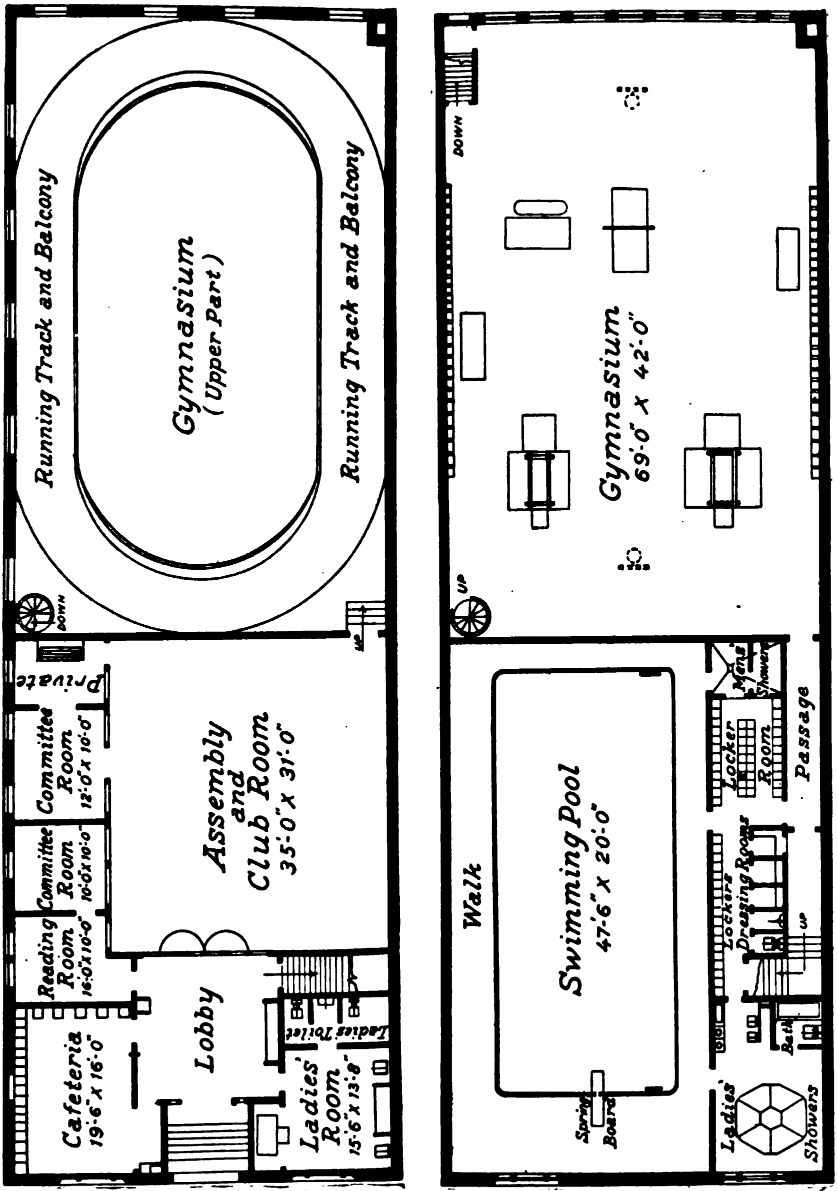


FIG. 42.—Gymnasium and social center building at Marysville, Kans.

A donated building erected in 1912 at a cost of $14,000 in a town of 2,300 population surrounded by a large farming community. The water in the swimming pool is heated by circulation through a tubular boiler. The running track is used also as a gallery for spectators of roller skating or the basket-ball games. Such a race track adds greatly to the cost of building.


Running Track and Balcony
Gymnasium
(Upper Part)
Running Track and Balcony
DOWN
UP
Private
Committee Room 12'-0" x 10'-0"
Committee Room 10'-0" x 10'-0"
Reading Room 16'-0" x 10'-0"
Assembly and Club Room 35'-0" x 31'-0"
Lobby
Ladies' Toilet
Cafeteria 19'-6" x 16'-0"
Ladies' Room 15'-6" x 13'-8"
DOWN
Gymnasium 69'-0" x 42'-0"
UP
Walk
Swimming Pool 47'-6" x 20'-0"
Spring Board
Men's Shower
Locker Room
Passage
Lockers Dressing Rooms
UP
Bath
Ladies'
Showers

FIRST FLOOR PLAN BASEMENT PLAN

FIG. 43.—Plans of Marysville building. (By courtesy of Boillot & Lauck, architects.)

CHURCH-CONTROL FEATURE.

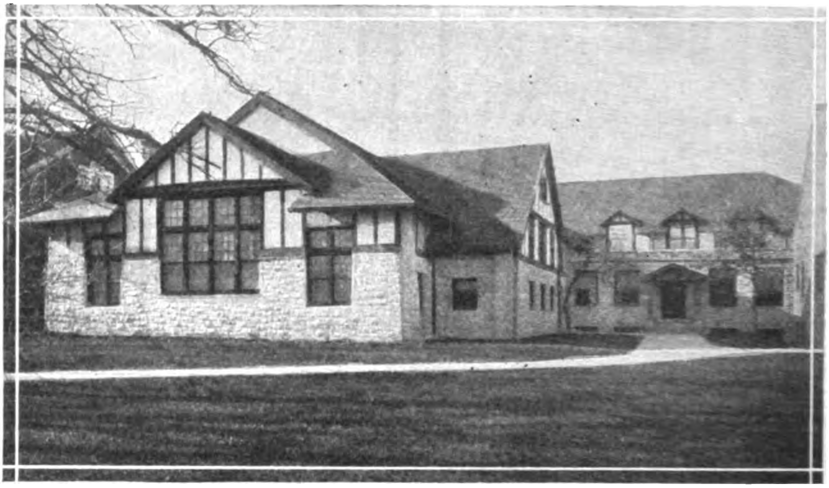


FIG. 44.—Community house at Winnetka, Ill.

A well-planned building for club and organization use in a suburban town of 3,000 inhabitants. While the title rests with a church, it was financed by general contribution, is managed by a nondenominational board of trustees, and is used by the whole community. It was completed in 1911 at a cost of $36,000. The number of club rooms of various sizes serves to give an idea of the number of organizations which use the building. The gymnasium is used as an auditorium, while the kindergarten room is used as a small assembly room. The kitchen serves both halls with almost equal facility. Women from the country find the neighborhood room of great convenience, while the various club rooms are available for the use of agricultural organizations.

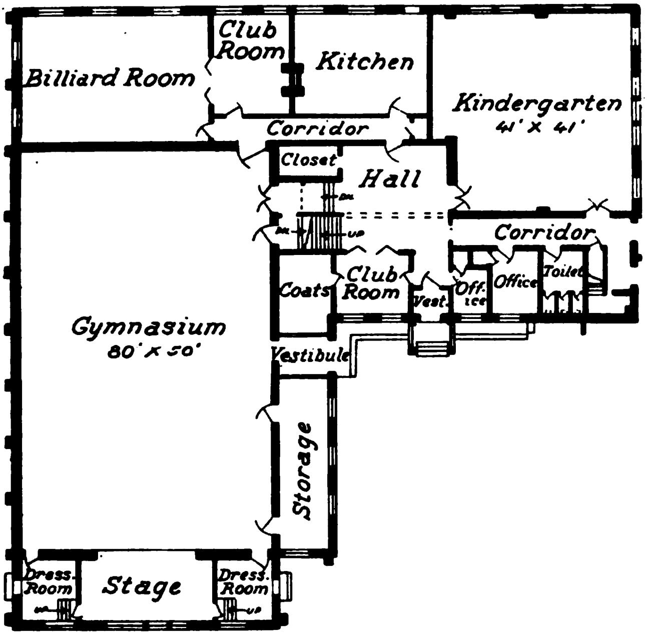


FIG. 45.—First-floor plan, Winnetka building. (By courtesy of A. S. Coffin, architect.)

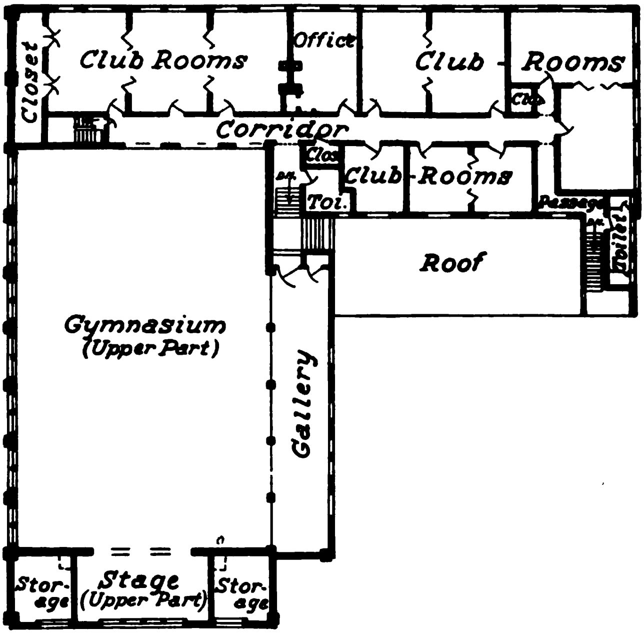


FIG. 46.—Second-floor plan, Winnetka building.

MUNICIPAL FEATURES.

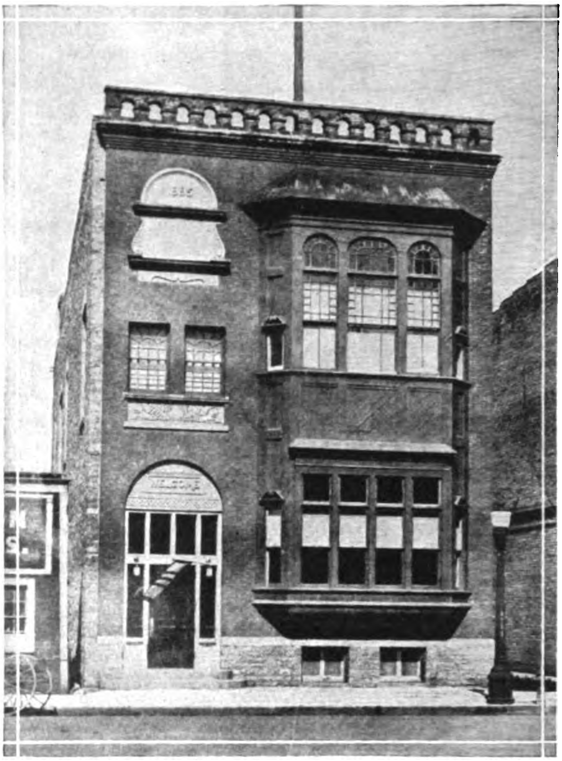
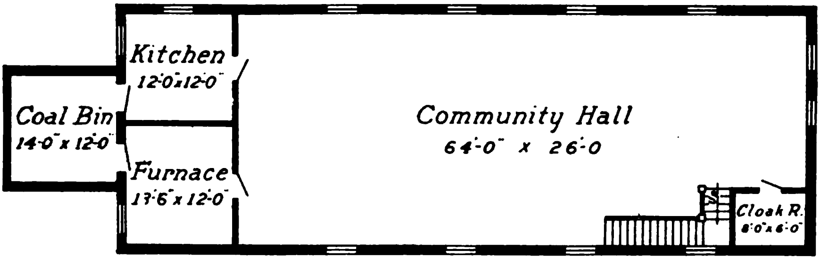
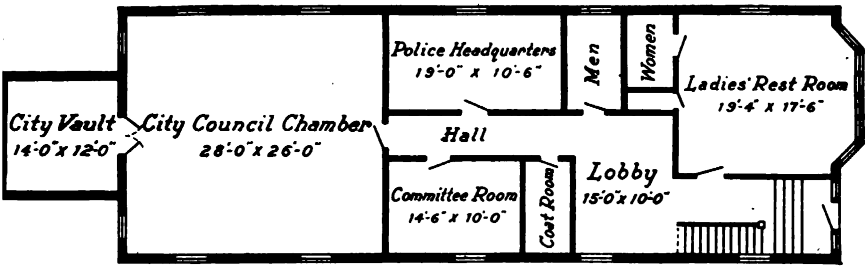


FIG. 47.—Community building at Northfield, Minn.

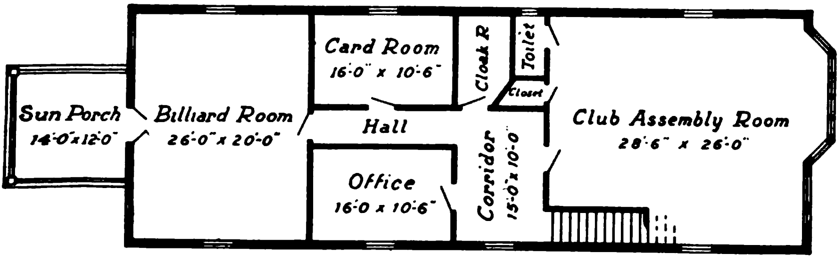
The community club, a combination of the old commercial club and civic club, sponsored this building as the center of a new movement in the direction of town and country cooperation. A building was purchased and reconstructed in 1918 at a cost of $26,000, financed by (1) general contributions of the 300 members, one-third of them farmers, (2) a moderate donation, (3) a contribution by the municipality by virtue of which it has the use of one floor, and (4) receipts from carnivals, socials, minstrel shows, and sales given under the auspices of the women's community council. The ladies' rest room is a convenience to country women, while the assembly hall and kitchen are useful to the 15 farmers' clubs in the near-by rural section. Northfield has a population of 3,200.



BASEMENT PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

FIG. 48.—Plans of Northfield building.

FARMING AND SMALL CITY.

FARMERS' REST ROOM FEATURE.

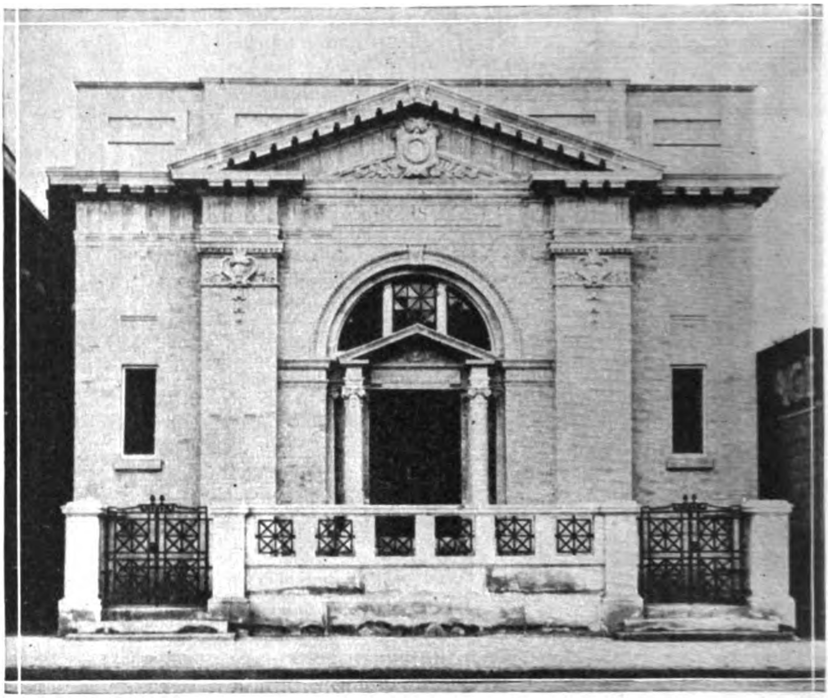


FIG. 49.—Farmers' clubhouse at Seymour, Ind.

A donated clubhouse for the exclusive use of residents of the farming community, erected in 1914 in a small city of 6,000 population. Maintenance in perpetuity is provided for through an endowment. Membership in the Farmers' Club (Inc.), of which there are more than 1,000 families, is secured by filling out application cards. The building is architecturally pleasing, as the dignified lines of the picture indicate, is finely furnished, and as nearly fireproof as possible.

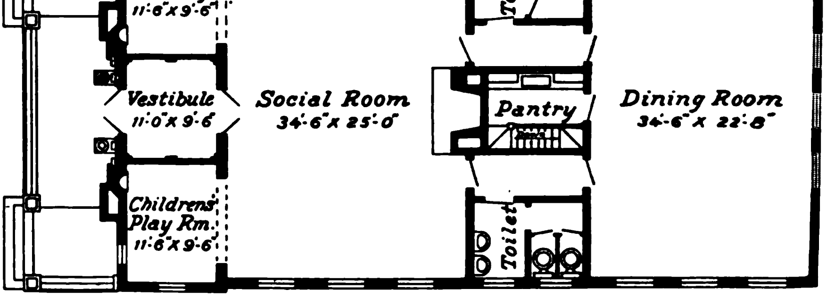


FIG. 50.—Floor plan of Seymour building. (By courtesy of John Bacon Hutchins & Sons, architects.)

RECREATION FEATURE.

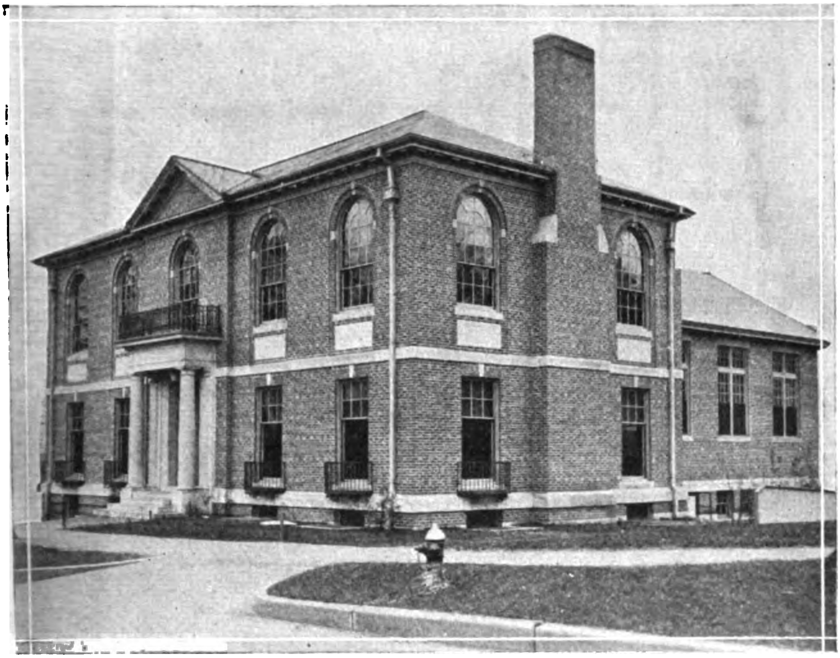


FIG. 51.—Community building at Lebanon, N. H.

A donated community building of excellent design and complete as to detail, located in a small city of 5,000 population. Erected in 1917, at a cost of $42,000, for the benefit of the people of the town and surrounding farming community. Nearly every feature of community life can find expression in this building. Out-swinging doors, spacious halls, and wide, gradually sloping stairways facilitate quick movement of people. The assembly room, though on the second floor, is provided with adequate exits. Every room possesses a fireplace and is well furnished, while the building possesses up-to-date lighting, heating, and plumbing facilities.

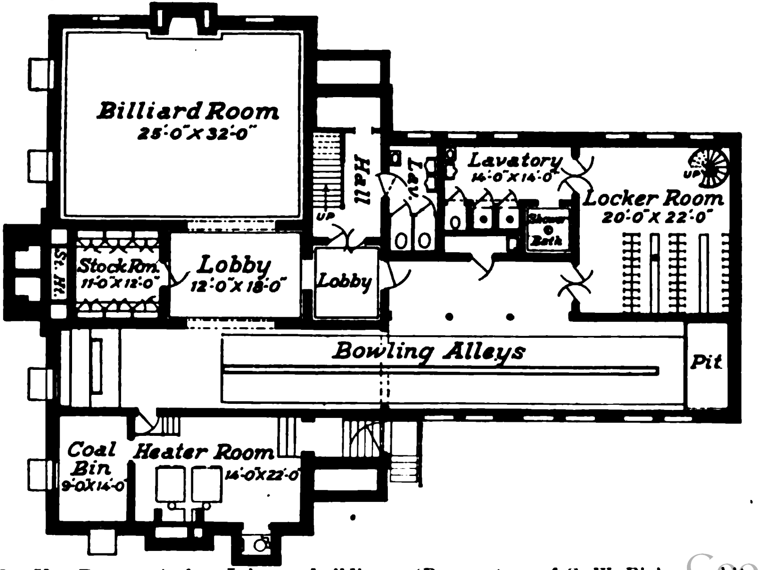


FIG. 52.—Basement plan, Lebanon building. (By courtesy of C. W. Bixby, architect.)

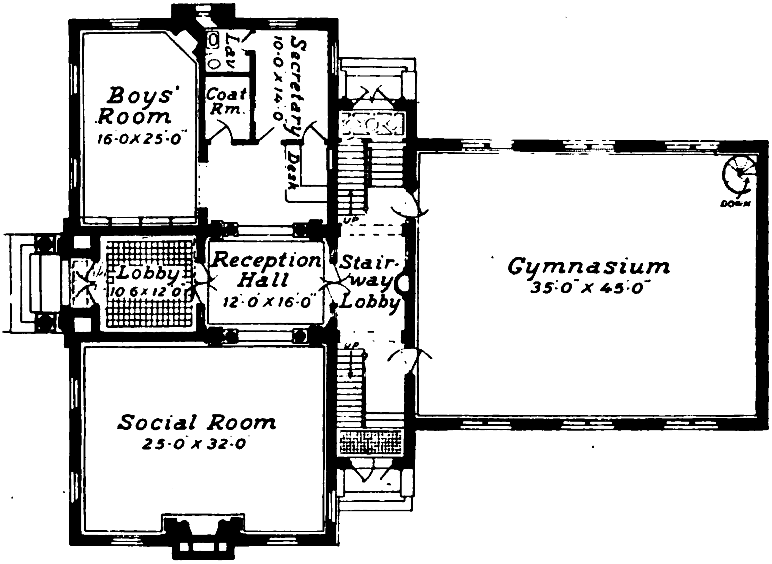


FIG. 53.—First floor plan, Lebanon building.

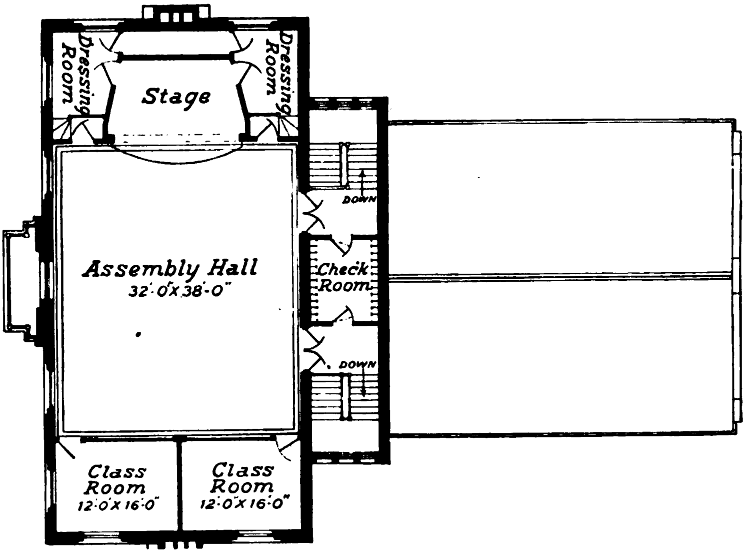


FIG. 54.—Second floor plan, Lebanon building.

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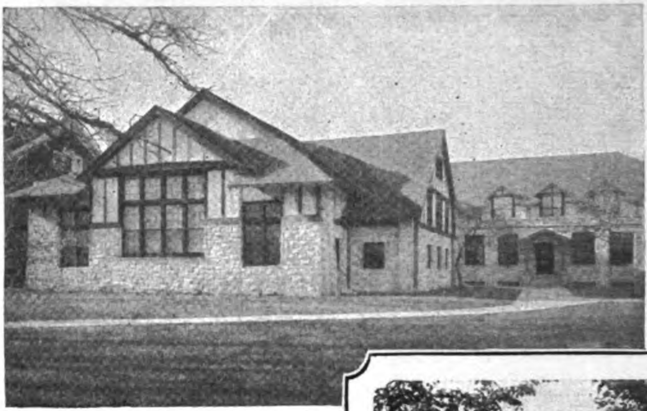

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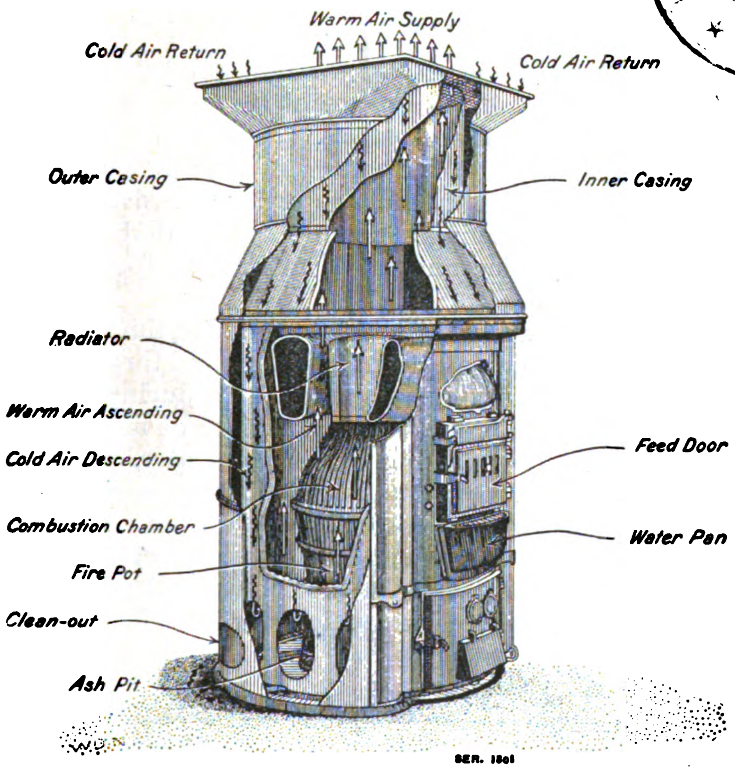
ONE-REGISTER FURNACES

(PIPELESS FURNACES)

A. M. DANIELS

Assistant Mechanical Engineer
Division of Rural Engineering

UNIVERSITY GENE 19



SER. 1801

Typical One-register Furnace

FARMERS' BULLETIN 1174

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Public Roads
THOS. H. MacDONALD, Chief

Washington, D. C. December, 1920

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

THIS bulletin discusses the principles and the advantages and disadvantages of the one-register warm-air house heating system. It is not the purpose to recommend this system in preference to others but to present the facts in order to assist the householder in selecting a heating system that will give the best service and most satisfaction for the money expended.

The system of warm-air heating treated in this bulletin is that in which all the heat is supplied through one register. It has come into much favor during the last few years. It is known by a variety of names, one-pipe, pipeless, one-heater, single-heater, one-register, or single-register, and not infrequently by the name of the manufacturer of the furnace. This bulletin explains the system, illustrates the circulation of cold and warm air in the rooms, and points out conditions under which satisfactory service can be expected.

Contribution from the Bureau of Public Roads
THOS. H. MacDONALD, Chief
Washington, D. C. December, 1920

ONE-REGISTER FURNACES.

(PIPELESS FURNACES.)

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Construction of the furnace	3	Means of heating a detached room	10
Circulation of air	4	Advantages of the one-register furnace	11
Factors affecting its suitability	7		

PRINCIPLE OF THE SYSTEM.

THE principle of the one-register system of warm-air heating, which has come into prominence during the last few years, is by no means new. Some fifty or sixty years ago a patent was granted for a stove with a jacket around it, to be placed in the basement, which, it was claimed, would deliver enough heat through a single opening in the floor above it to heat an entire house. The original idea, however, provided no means for removing from the rooms the cold air which the heated air must displace in order to warm the house properly. Consequently, success never crowned the efforts of the original inventor.

Subsequent endeavors produced the present one-register furnace, which may be considered, and not improperly, the successor to the base-burner. The single-register furnace is applicable to work that may be accomplished with stoves of large size but its performance is much better. It distributes warm air more rapidly and evenly because it draws away the cold air from the floor.

CONSTRUCTION OF THE FURNACE.

The typical construction of the furnace is shown on the title page. It consists essentially of a heater with a single register located directly above. The register has two parts, the center portion through which warm air passes upward and the outer portion which conducts the cooler air downward between the outer and the inner casing to the base of the furnace. From there it recirculates upward around the heating surfaces of the furnace and then out again through the hot-air part of the register. The arrows in the illustration indicate the direction of the cold and warm air currents.

Figures 1 and 2 show, respectively, the floor plan and a section through a five-room farmhouse. In this design all rooms are on one floor. This example of a one-register furnace with the warm and cold air outlets located as shown illustrates the air circulation which must occur to obtain satisfactory heating. Figure 3 shows this type of furnace installed in a six-room, two-story farmhouse. The arrows indicate the desired circulation.

CIRCULATION OF AIR.

As the heated air leaves the central part of the register it rises straight to the ceiling and diffuses through all the rooms that open into the main room or hall in which the register is located, provided the door openings extend well up to the ceiling and no hangings interrupt the circulation. If there is an open stairway, part of the heat will circulate to the upper hall and enter rooms that open into it. A register placed in the ceiling of a downstairs room under some conditions may offer greater assurance of heating the room directly above if it is desired that the room should be heated to a higher temperature than other second-story rooms. Ceiling registers, however, should not be considered always as warm-air passages; they not infrequently may be cold-air returns. The result depends upon the arrangement of stairways and lower and upper story rooms.

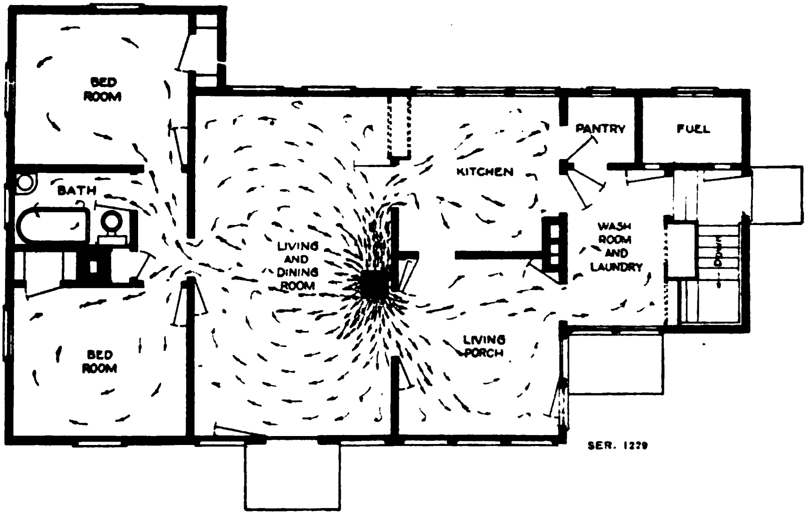


FIG. 1.—Floor plan showing the circulation of warm and cooled air from a one-register furnace.

As the heated air diffuses through the house the colder and heavier air falls to the floor. From there it is drawn back continually into the furnace through the return inlets. It is apparent that since all the air circulates through one register, which has a relatively small area as compared to the volume of the house, a concentration must occur at this part of the system. This is sometimes noticeable to one sitting near the register by a circulation of cooler air around the feet; if very uncomfortable, the principal contributing cause may be air from without that flows to the register from under an

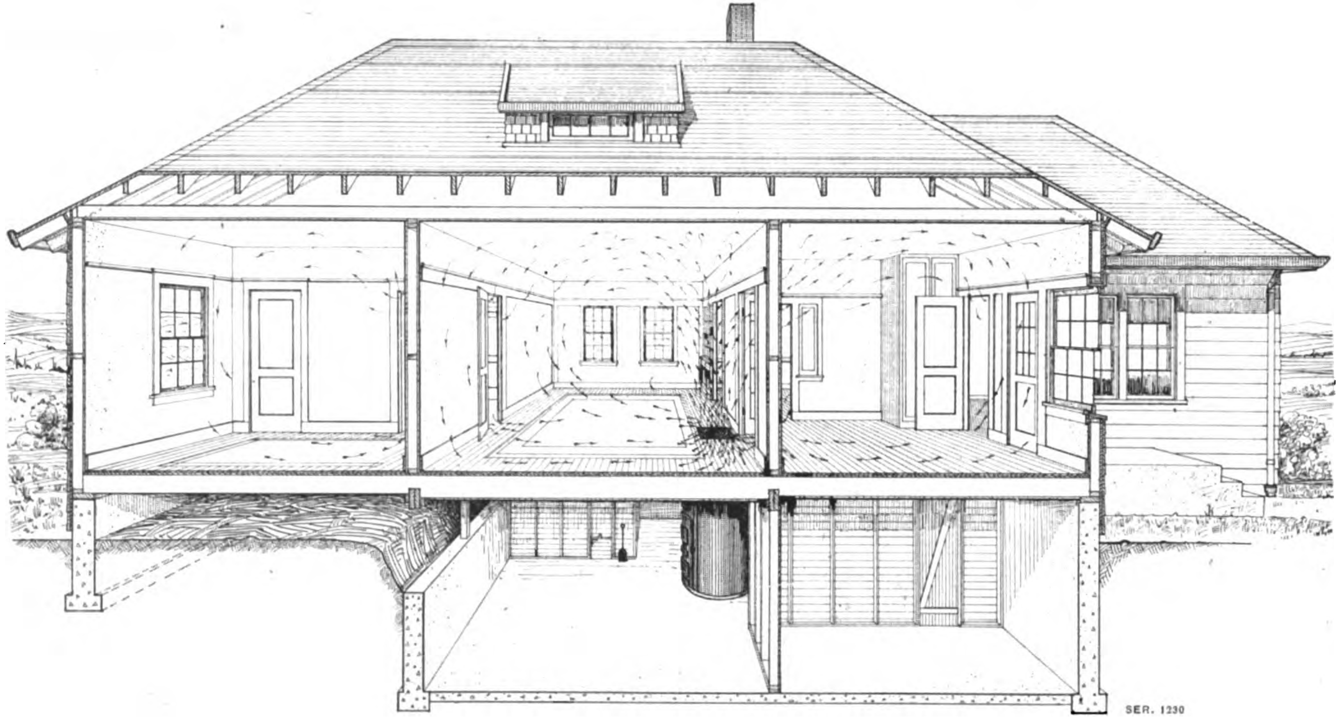
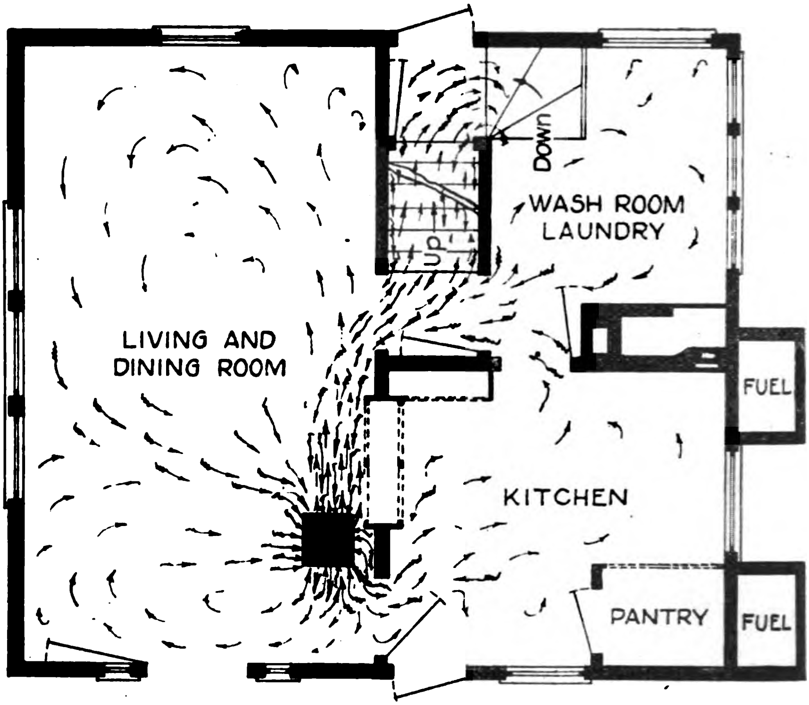
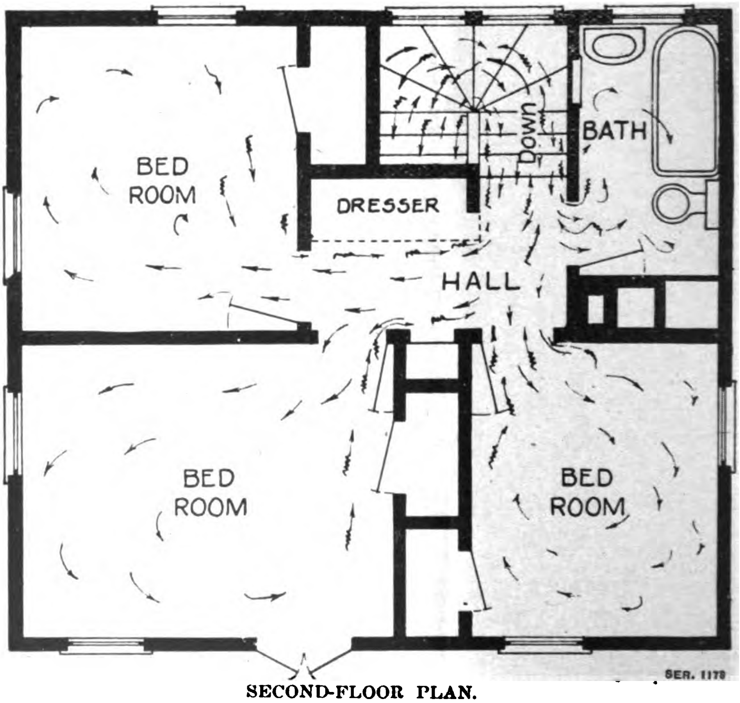


FIG. 2.—Interior view of house showing the circulation of warm and cooled air from a one-register furnace.



FIRST-FLOOR PLAN.



SECOND-FLOOR PLAN.

Fig. 3.—Floor plans of a six-room house showing the circulation of warm air and cooled air from a one-register furnace.

outside door or opening in line with the register. By some this draft of cooler air, whether flowing from the inside or outside, is considered a drawback to the system. One might think that the room in which the register is situated would receive too much heat, but experience generally proves that this is not the case. The warm air diffuses quite evenly, producing, usually, a comfortable temperature which at the same level seldom varies more than a few degrees at different points throughout the building, provided the arrangement of the house is suitable for a one-register furnace installation.

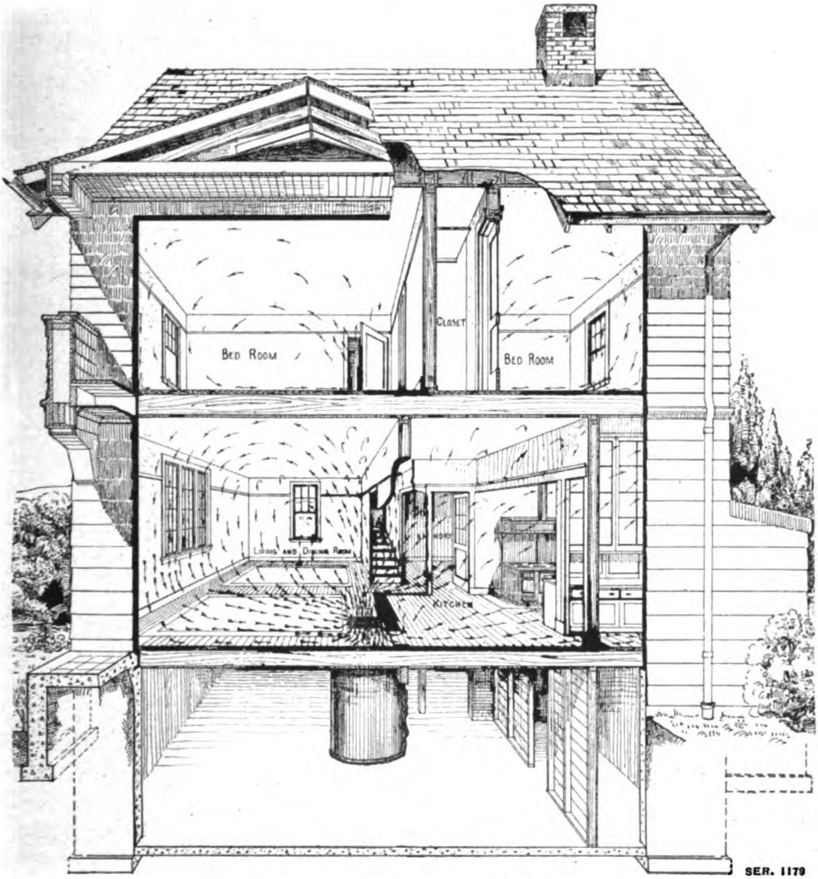


Fig. 4.—Interior view of six-room house, showing the circulation of warm air and cooled air from a one-register furnce.

FACTORS AFFECTING ITS SUITABILITY.

It is impossible to describe definitely the conditions under which the installation of a one-pipe furnace should be recommended. There are a number of variable factors. The arrangement of the rooms is very important; there must always be an unobstructed passage for the air from room to room. Nothing must interfere with the air circulation nor divert it from any room that is to be heated. The number of rooms that may be effectively heated is open to question. A conservative manufacturer generally will not recommend it for any home until he has examined the plans of the house, and he will sell with the reservation that he does not agree to make comfortable rooms which do not open directly into the room where the furnace outlet is located. The following paragraphs are quoted from a "Proposal for heating" used by a large manufacturer of one-pipe furnaces:

> In consideration of payment of the purchase price at the time stipulated, we agree and guarantee that this furnace, properly operated, will furnish sufficient heat for all the rooms opening into the main room where the hot-air register face is situated.
>
> It must be understood that the method of heating from one register does not warm all rooms alike, and that rooms shut off from the room where the heating register is placed are not materially influenced by it. By the use of ceiling registers the upper rooms above that where the heat register is situated will be tempered comfortably for sleeping purposes. The main room with the heat register will be warmed without difficulty to a comfortable degree (70° F.) in coldest weather.

Another reliable firm gives a guaranty that "if, after 60 days' trial in cold winter weather the heater is not satisfactory, it can be taken out and returned to the manufacturers, who will, on their part, refund the original purchase price paid for it."

There have been, however, manufacturers of one-register furnaces whose enthusiasm has led them to make apparently extravagant claims for their product, even advertising to heat any house with this type of furnace. While there may be houses of exceptionally large size in which a one-register furnace has been installed and is giving satisfactory service, the fact should be considered as the exception rather than the rule. The requirements of families using a heating system may differ widely. What might be regarded as a satisfactory and efficient single-register furnace by one family by another family might be considered quite the contrary.

In one instance a conservative manufacturer, in spite of the greatest care in selling, with agreements that excepted attempts to heat other than the main living room, found it necessary to replace the one-register furnace by a pipe furnace in houses of five to eight rooms in order to have certain rooms heated to a desired temperature. Contrasted to this is one gentleman who states that his 16-room house, with no storm windows, was perfectly warmed through a severe Vermont winter by a furnace that the manufacturer rated at seven or eight rooms' capacity.

Many families prefer and others demand cool bedrooms, and an apparatus that warms those rooms to a temperature above 50° or 60° F. is not required. On the other hand, some families, especially those in which are elderly or delicate members, require warmer halls and sleeping rooms. Under such conditions particularly the limitations of this system should be considered. In cold winter weather too much reliance probably should not be placed in a one-register installation if a temperature of 70° and upward is required in second-story bedrooms, halls, bathroom, kitchen, or any rooms that are detached or distant from the main room in which the register is placed.

LIMITATIONS OF THE ONE-REGISTER FURNACE.

The one-register furnace is no exception to the rule that everything has advantages and disadvantages and must prove itself before it will receive recognition. When the one-register furnace, as a commercial article, was new many manufacturers were inclined to question the correctness of some apparently extravagant claims that had been made regarding it, although they did not doubt the honesty of the writers. Longer experience has convinced those that then composed the more conservative group that many of the statements were correct in their essential features.

This, however, does not establish the universal suitability of the one-register furnace for all houses, but should rather impress a prospective owner with the advisability of proceeding with as much caution in the purchase of one, as the manufacturers showed in finally indorsing it.

To-day there are perhaps thousands of instances where this system of heating is in operation with complete satisfaction, and where the owner would now consider no other. These cases, however, do not include houses in which one or more rooms are shut off from the others, nor are they often found in one-story houses where the grouping of the rooms is long rather than square;[1] or in two-story houses of more than 8 or 10 rooms where the dimensions of the house exceed a length of about 40 feet and a width of about 30 feet.

Some advocates of this system claim that it has a distinct advantage over the ordinary warm-air furnace for the reason that in the ordinary furnace a pipe 10 inches in diameter, which has an area of slightly more than one-half square foot, must carry all the warm air for each separate room from the furnace, whereas the doorways, through which the heat from the one-register furnace is transmitted, are about 17 square feet in area, approximately 35 times as great as the pipe area. The argument has indeed been used that, instead of carrying the heat through a small pipe, you carry it through the door openings, or rather you do not have to carry it, it simply goes in. This may seem convincing at first thought, but it should be remembered that warm air may be delivered into a room directly from the furnace through a separate pipe at a higher temperature than when it is made to circulate through doorways, for as air circulates from one room to another of lower temperature it becomes cooled; consequently the farther it has to go and the longer it takes the less heat will it contain when it finally reaches the room farthest from the register. One is more certain, therefore, of obtaining the necessary amount of air at any desired temperature by means of a direct pipe from the furnace.

---

[1] Some manufacturers do not advise trying to heat over 1,500 square feet of floor space on one floor.

One of the essential requirements of the system is to install the furnace approximately under the center of the first floor, while for warm-air pipe heating it is considered in the interest of good design to place the furnace nearer the windward side of the house in order to favor the colder side on windy days with shorter pipe runs.

The argument has been advanced that the one-pipe furnace acts as a sort of atmospheric sterilizer by removing dust and germs from the heated rooms. If the circulation is strong enough some particles of dust floating in the rooms are no doubt carried to the furnace, pass through it and are again discharged into the rooms. If much dust is present it will settle on nearby objects, and even discolor walls and curtains, but the air is neither contaminated nor purified by circulating through the heater.

This system does not provide ventilation, since it recirculates the air over and over again and must depend on the opening of doors and windows and on infiltration for its supply of fresh air, though in this it does not differ from most residential hot-water, steam, or vapor plants. Warm-air pipe furnaces, when properly installed, include a fresh-air inlet.

MEANS OF HEATING A DETACHED ROOM.

Probably more skepticism has been expressed about the ability of the one-register furnace to heat the bath or other closed or detached room than about any other claim that is made for it. Since the success of the system depends on the transfer of heat from room to room through the doorways, it is clear that the closing of the door of any room other than the one in which the register is located will cut off the supply of heat to that room. If, therefore, the room is one which it is necessary to keep closed, such as the bathroom, it may be necessary to provide other means of maintaining the desired temperature. To remedy this partially, transoms may be provided over the doors. These can then be left open, but an opening should also be left at the bottom of the door. Another plan is to install a hot-water radiator connected with an ordinary range boiler, like the arrangement shown in figure 5; or, if there is sufficient space, and there is no objection to the appearance, the range boiler may be located in the bathroom and connected to a water coil in the furnace, provided the latter has proper openings. The radiation from this boiler is frequently sufficient to heat the room to the desired temperature. Still another method, shown in figure 7, is to use a furnace in which a part is partitioned off and dampered so that the air heated in that part may be directed through a separate pipe to the bath or other detached room. When heat is not required in that room, it may be directed through the large register by altering the position of the damper. While such a plan is feasible, the system with that arrangement could not properly be classed as a one-register installation.

ADVANTAGES OF THE ONE-REGISTER FURNACE.

The one-register furnace is a valuable addition to the means of heating houses and, particularly, stores, halls, churches, shops, etc.

It is comparatively simple to install. Installation by a good mechanic familiar with the heating business offers greater certainty than if the work is done by an inexperienced person.

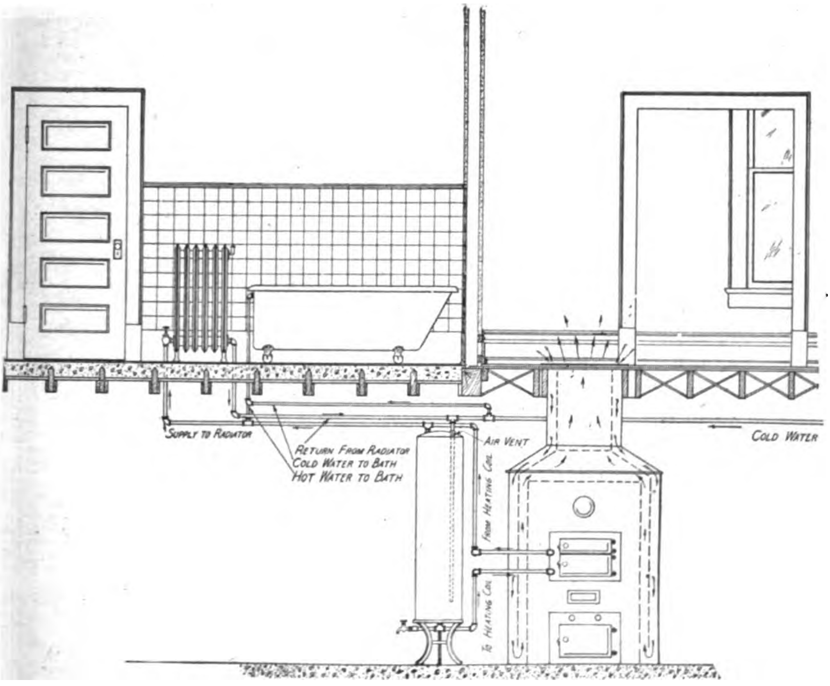


Fig. 5.—Bath and other detched rooms which may necessarily be closed off from the rest of the house can often be heated satisfactorily by using a hot-water rdiator in connection with the one-register furnace. When this scheme is used, the safety valve on the boiler should be set so that the pressure in the system will never become excessive.

The price of a one-register furnace installation is moderate, and within the reach of every householder who can afford a large baseburner of the better sort. Within its field, therefore, it offers to those who heretofore may not have felt that they could afford a heating plant an opportunity to get real heating comfort at a moderate price. It presents a means of heating many old houses in which the installation of a first-class pipe heater would be too expensive to justify consideration.

The cost of operation in nearly all instances is less than that of a warm-air pipe furnace. The cause of this slight difference in its favor is its more perfect insulation in the cellar. The downflowing current of cooled air absorbs the heat given off by the jacket of the heating chamber and carries it down and up again through the warm-air chamber and thence into the rooms above, whereas in the ordinary type of warm-air heater the heat radiated by the casing of the heating chamber is dissipated in the cellar unless the heater is covered with insulation. Also, the circulation of air over the heated castings is much more rapid, as the discharge is directly upward without the resistance due to friction in pipes.

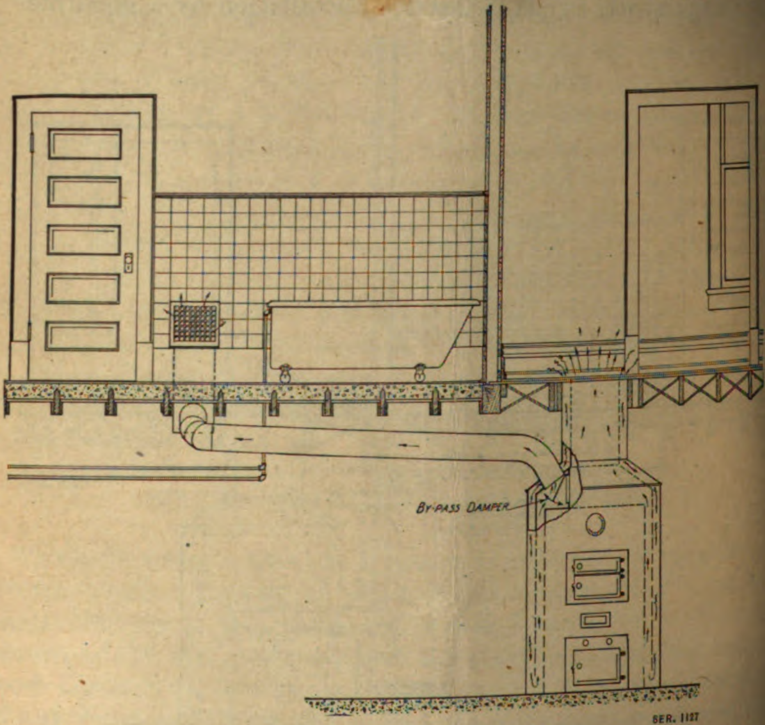


FIG. 6.—The same result as illustrated by fig. 5 may be accomplished by using a partitioned heater. The installation then can not properly be classed as a one-pipe furnace.

A one-register heater may replace two or three stoves. It offers a more easily regulated heat, and requires no dismantling in the spring and reinstalling in the fall. The number of fires to take care of is reduced to one, and all handling of fuel and ashes is confined to the basement.

There is no doubt that, for conditions to which it is suited, the one-register furnace system is both efficient and satisfactory, but to secure an effective installation it is sometimes necessary to sacrifice architectural or decorative effects which generally are accepted as desirable.

CORN YIELDS can be increased more surely and more cheaply by the use of better seed than in any other way.

Seed corn should be selected in the field from stalks which yield best in equal competition with others. It should be of a variety which succeeds well and matures under local conditions. Ears should be saved only from stalks free from disease. Drooping ears which shed rain readily should be selected, and these should be borne on the stalks at a convenient height for husking. In the South, ears which are well protected from insects by a long, tight shuck covering should be chosen.

The same day the seed is gathered it should be hung in a dry, airy place. One of the best ways to cure seed corn is to hang it from the rafters of a barn or open shed. It should not be allowed to freeze before it is thoroughly dry. After it is well cured it should be stored in a dry place where it will remain secure from mice, rats, birds, and insects. Well-cured seed corn will yield a much better crop than seed originally as good but injured through lack of care.

Generally speaking, the seed corn that produces the best crop is the cheapest. Farmers are justified in devoting considerable time to selecting and caring for it or in paying good prices if better seed corn is purchased.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1920

BETTER SEED CORN

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LOW YIELDS DUE TO POOR SEED CAN BE PREVENTED.

THE AVERAGE ACRE YIELD of corn for the entire United States is but 26 bushels, yet in practically every section two or three or even four times that quantity frequently is produced. Improving the quality of the seed corn is one of the surest ways of increasing the yield.

Each spring good seed corn is scarce. This condition is entirely unnecessary, and it is much more serious than is commonly supposed, because many do not fully realize the tremendous loss to themselves and the country caused by planting inferior seed. A full stand may be obtained from inferior seed, but the yield will be lower than good seed would have produced.

The loss is due to delay or negligence. It usually can be prevented by the selection of seed corn in the field in the fall. If good seed corn could be manufactured in a few weeks' time, factories would be working day and night from March until June. Each spring many correspondents inform the United States Department of Agriculture of their willingness to pay good prices for good seed corn and of their inability to obtain it.

THE VERY BEST SEED IS AVAILABLE AT RIPENING TIME.

Autumn is the time to prepare for a profitable corn crop in the following season. This bulletin should prove more valuable and timely than any replies that can be written to springtime correspondents regarding seed corn. Its object is to prevent the scarcity of first-class seed corn each spring. This scarcity can be prevented by

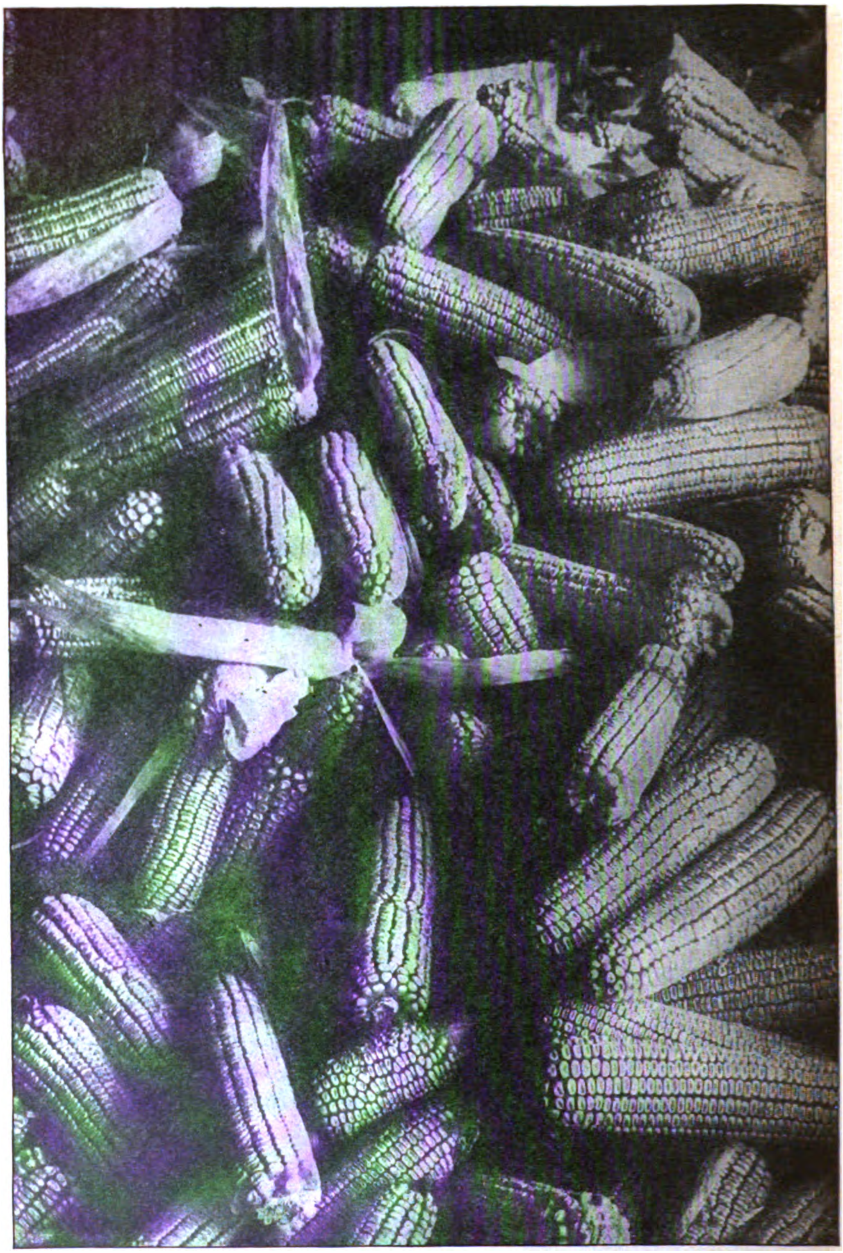

Fig. 1.—U. S. Selection 77 corn in crib in southern Ohio, just as it came from the field. Twenty years of seed selection have greatly increased the productivity of this variety.

selecting a two years' supply of seed when it is most abundant and when the very best can be obtained, at ripening time, before it has been in any way reduced in vitality and productivity. Many let this opportunity pass, expecting to purchase their seed corn, only to find in the winter or spring that they can not buy at any price as good seed as they could have selected in the autumn. Figure 1 shows a fair sample of what well-bred, well-selected seed corn will produce.

WHERE TO OBTAIN THE BEST POSSIBLE SEED CORN.

Unless a community has its experienced and honest corn breeder, the best place for the farmer to obtain seed corn is from the fields on his farm or in his neighborhood which were planted with a variety that generally has proved successful in the locality.

CORN BREEDING IS A SPECIAL LINE OF WORK.

Some farmers buy all their seed corn, others buy only enough every few years to produce their own seed for main-crop planting. Which is the better plan depends upon whether the farmer can produce as good seed and care for it as well as the person from whom he buys.

Well-conducted corn breeding requires special methods that farmers generally do not have time to apply. If there is in your locality a corn breeder who demonstrates each year the superiority of his corn, you can afford to pay him well for his superior seed. Five dollars a bushel should prove a profitable price for both parties under ordinary conditions. Such corn breeders are improving various kinds of corn, just as cattle breeders are improving various breeds of live stock by breeding from the most profitable individuals.

The general farmer is a producer rather than a breeder of corn. He profits by the careful work of the corn breeder by adopting the higher yielding strains for his general crop. However, he must remember that all the corn grown from the bushel of purchased seed is not necessarily as good for seed as was the original bushel. Some of it may be better, but much of it is likely to be poorer. Corn is constantly producing variations and mutations, and can be improved thereby or allowed to "run out."[1]

WHAT CONSTITUTES GOOD SEED CORN.

Too many people consider seed good simply because it will grow. To be first class, seed must be—

(1) Well adapted to the climatic and soil conditions where it is to be planted.

(2) Of a high-yielding variety and from the high-yielding stalks of that variety.

(3) Well matured and preserved from ripening time till planting time in a manner that will retain its full productivity.

(4) Free from disease and insect injury. Such freedom may indicate resistance to infection.

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[1] Those especially interested in the improvement of corn by methods of breeding can receive detailed information upon application to the Secretary of Agriculture.

The importance of these four requirements has been fully demonstrated by experiments. Brief statements of the experimental evidence follow:

(1) During five years 12 well-bred varieties were compared in 10 Northern States, equivalent lots of seed being planted in each State. Varieties that produced most in some States were among the poorest in others.

(2) Seed ears taken from the highest yielding rows of ear-to-row breeding plats have repeatedly produced better than seed ears taken from poorer yielding rows. Seed ears from the highest yielding stalks found in a general field produced better than equally large and good-appearing seed ears taken without considering the inherent productiveness of the parent stalks.

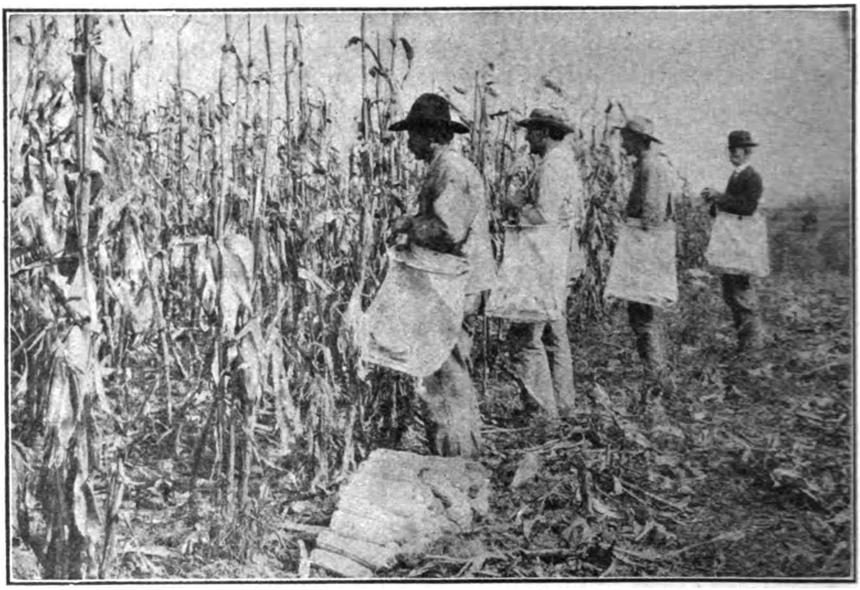

FIG. 2.—A field of corn, showing a good method of selecting seed. The men are searching for plants that have produced heavily under average conditions and in close competition with less productive plants in the same and adjacent hills.

(3) Four hundred ears were divided into two equal lots, one lot being well cared for and the other placed in a barn as corn ordinarily is cribbed. The well-preserved seed produced yields 12 per cent higher on poor soil and 27 per cent higher on fertile soil than that poorly preserved, notwithstanding the fact that both lots of seed germinated equally well.

(4) Diseased ears or apparently healthy ears from diseased shanks or stalks have given lower yields than disease-free ears from normal stalks. Apparently healthy ears were selected and separated by test on a special germinator into actually diseased and disease-free lots. The average acre yield from the ears shown to be diseased was 15 bushels less than that from the sound ears. For a full discussion of the selection of seed corn free from the rot diseases of roots, stalks, and ears, see Farmers' Bulletin 1176.

HOW TO GATHER SEED CORN.

MAKE SEED-CORN GATHERING A SPECIAL TASK.

At corn-ripening time drop all other business and select an abundance of seed corn. The work is too important to be conducted incidentally while husking. When selecting seed corn give it your entire attention and select for the one most important character, the power to yield well. Get the very best that is to be had and dry it promptly, and your increased yields will return you more profit than any other work you can do on your farm.

The only proper way to select seed corn is from the stalks standing where they grew, as soon as the ears are ripe and before the first hard freeze.

SELECT ONLY FROM THE BEST-PRODUCING PLANTS.

As soon as the crop matures go through the field with a picking bag (fig. 2)[2] and husk the ears from the stalks that have produced the most good corn without having had any special advantages, such as excess of space, moisture, or fertility. Avoid the large ears on stalks standing singly with an unusual amount of space around them. Preference should be given the plants that have produced most heavily in competition with a full stand of vigorous plants (fig. 3).

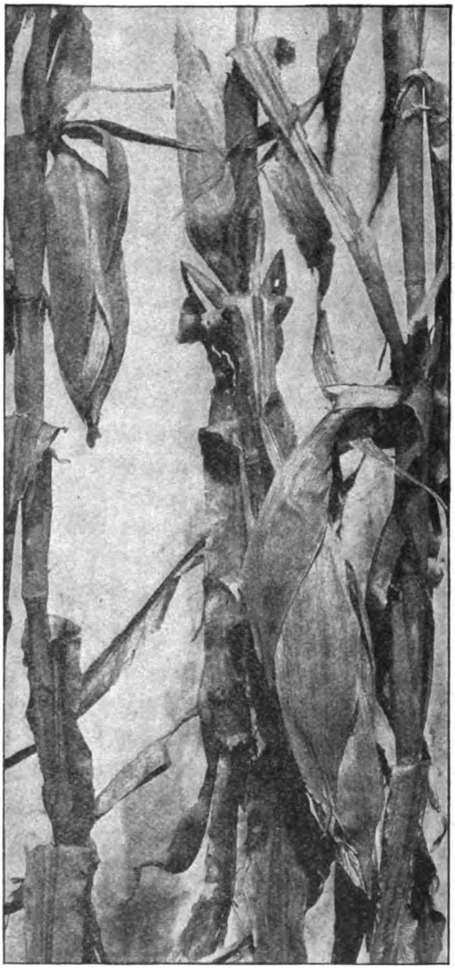

FIG. 3.—The three seeds planted in this hill evidently differed in their heritable characters. One ear is erect, permitting water to enter; two are small and too high. In gathering seed, only the large ear at convenient height should be considered.

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[2] The picking bags shown in figure 2 are always open for filling and may be instantly opened at the bottom for emptying.

In all localities the inherent tendency of the plant to produce heavily of sound, dry, shelled corn is of most importance. A well-balanced stalk (fig. 4) bearing two long ears will usually be found to have produced as much grain as any other stalk. Both ears are equally valuable for seed, even though one may be much smaller than the other.

Late-maturing plants with ears heavy because of an excessive amount of sap should be ignored. Sappiness greatly increases the harvest size and weight, but is likely to destroy the quality.

In the Central and Southern States, all other things being equal, short, thick stalks are preferable. They are not so easily blown down and in general are more productive than slender ones.

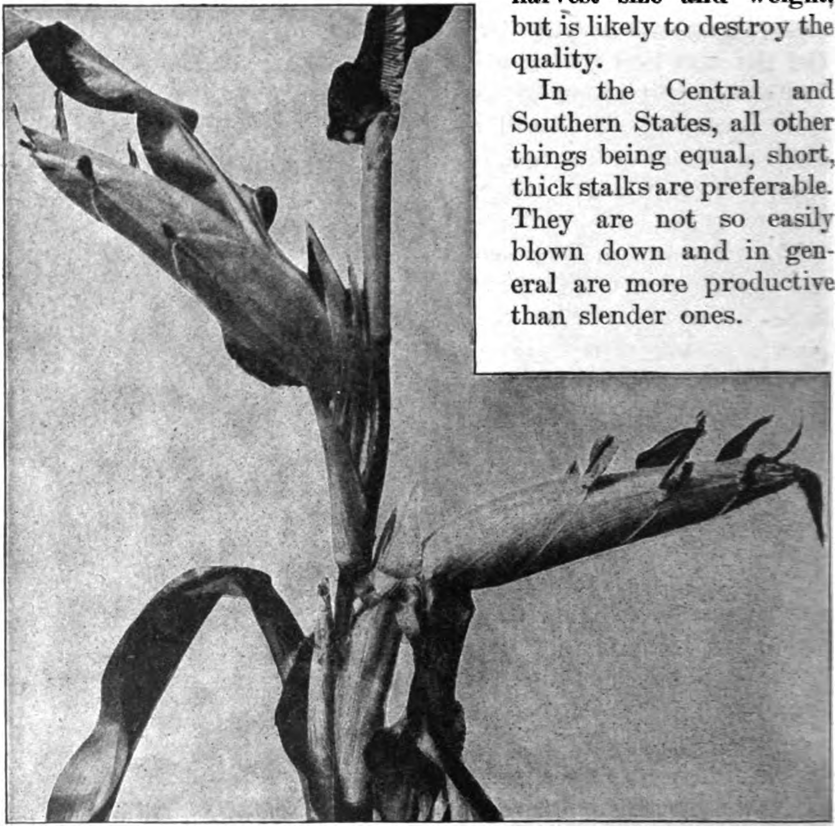

FIG. 4.—The number of ears on the stalk can be controlled by hybridization and by selection. Two ears balance well on a stalk, but a variety should be allowed to vary in the direction in which it yields most abundantly of good grain.

In the more northern States two varieties usually are desirable, an early-maturing variety for grain and a later, ranker growing one for ensilage. Vigorous seed of the ensilage variety usually can be obtained most advantageously from farther south, where it reaches full maturity. Such seed will stand unusually early planting. The ensilage variety should be planted two or three weeks earlier than the variety grown for grain, rather than later, as too often is the case. When planted in April or early May, ensilage varieties produce much more grain and mature much better than when planted late.

More rapid progress in acclimatizing higher yielding strains in the Northern States would be made if sufficient seed were selected from each well-matured crop to last till the next well-matured crop is obtained.

Our seed selection should be in cooperation with natural selection. "The survival of the fittest" should be recognized and seed selected only from individuals that have reproduced best and most abundantly. Seed should be selected only from individuals which have resisted smut and other harmful diseases.

The tendency to reproduce ears proof against weevils because of long, tight-fitting shucks should be used to advantage when selecting seed in weevil-infested States.

The tendency for corn to produce suckers is hereditary. Other things being equal, seed should be taken from stalks that have no suckers.

TREATMENT OF SEED IMMEDIATELY AFTER GATHERING.

The same day seed corn is gathered the husked ears should be put in a dry place where there is free circulation of air and placed in such a manner that the ears do not touch each other. This is the only safe procedure. The writer has repeatedly seen good seed ruined because it was thought to be already dry enough when gathered and that care in curing was unnecessary. Many farmers believe that their autumns are so dry that such care is not needed. In every locality seed corn gathered at ripening time will be benefited by prompt drying. If left in the husk long after ripening, it may sprout or mildew during warm, wet weather or be injured by freezing.

The vitality of seed often is reduced by leaving it in a sack or in a pile for even a day after gathering. During warm weather, with some moisture in the cobs and kernels, the ears begin to sour or mildew in a remarkably short time.

A good method of drying the seed ears immediately after gathering is shown in figure 5. Ordinarily the best place to hang these strings of ears is in an open shed or loft.

Wire racks, like those shown in figures 6 and 7, are more convenient and in the end cheaper than binder twine or cord. Credit for the idea of making such racks from electrically welded wire fencing is due to a seed-corn company. How to cut the fencing into seed-corn racks without any waste is shown in figure 7. Fencing having horizontal wires 4 inches apart and upright wires 2 inches apart may be obtained in widths of 2, 3, and 4 feet. Dealers can usually supply such fencing to farmers at an initial cost of about 10 cents for each bushel of seed suspended. These racks will last many years, and are light and easily stored when not in use. A wooden rack is shown in figure 8.

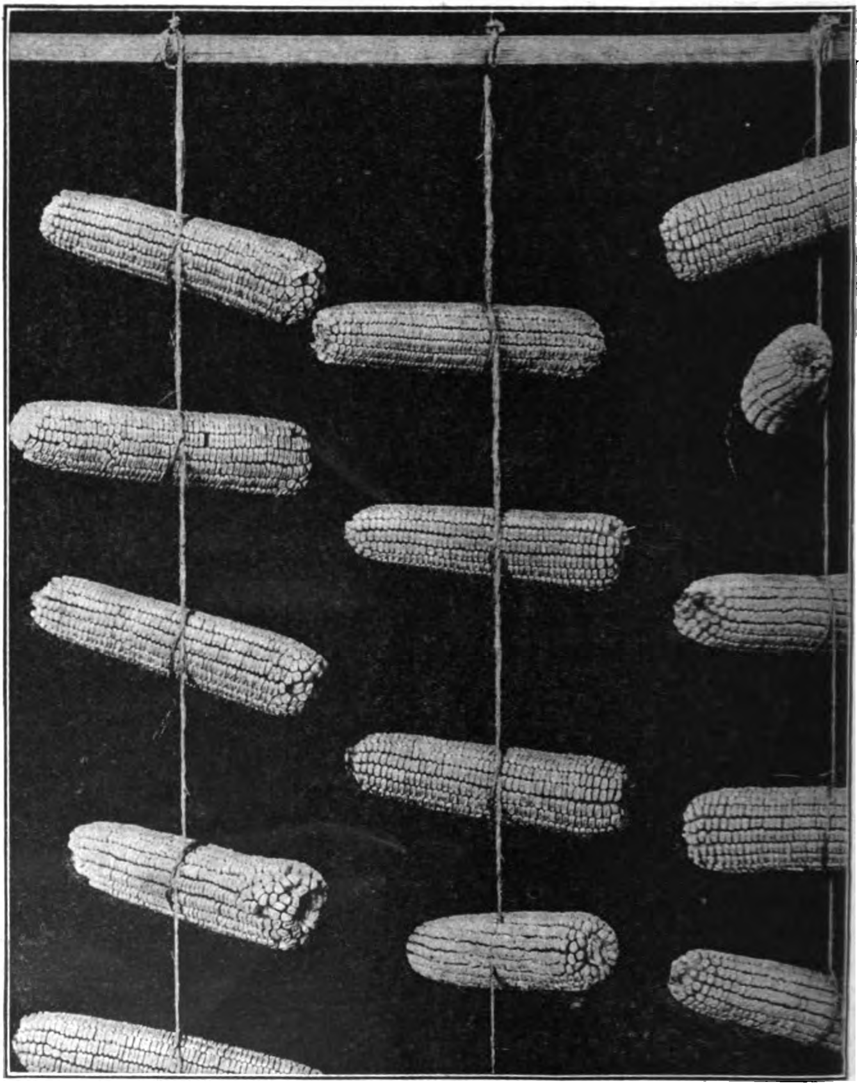

FIG. 5.—A good method of drying seed ears, stringing them immediately after they are gathered and hanging them in a breezy place.

Fire will be necessary only during unusually damp weather at seed-gathering time. If heat is employed in a poorly ventilated room it will do the seed ears more injury than good. If used, the fire should be slow, long continued, and situated below the seed ears, with good ventilation above them. The seed ears should not be allowed to freeze unless they are thoroughly dry.

WINTER STORAGE OF SEED CORN.

After hanging in the shed or lying on the racks for two months, the seed ears should be "dry as a bone" and contain less than 10 per cent of moisture. They can remain where they dried or be stored in mouse-proof barrels, boxes, or crates during the winter, but in either case must not be exposed to a damp atmosphere or they will absorb moisture and be injured. Some farmers place the thoroughly dried seed ears in the center of a bin and fill with loose dry wheat or oats. This protects the ears from rats and mice.

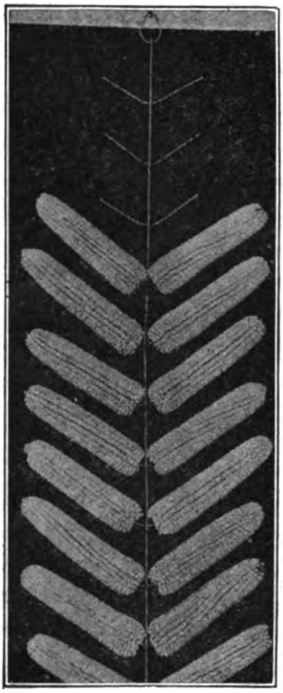

Fig. 6.—Seed ears suspended by means of wire racks made from electrically welded fencing. Figure 7 shows how to cut these racks.

PREVENTING INJURY BY WEEVILS OR GRAIN MOTHS.

If at any time signs of weevils or grain moths show on the dry seed ears they should be inclosed with carbon bisulphid in practically air-tight rooms, bins, boxes, or barrels for 48 hours. The bisulphid should be placed in shallow dishes or pans on top of the seed. A half pint is sufficient for a box or barrel holding 10 bushels or less. One pound is sufficient for a room or bin 10 feet each way. After fumigation the ears should be thoroughly aired, taking care that no fire is present when the fumigating box is opened, as the gas is explosive.

In localities where weevils and grain moths injure stored grain, the thoroughly dry seed ears should be stored in very tight mouse-proof receptacles, with 1 pound of moth balls or naphthalene inclosed for each bushel of corn. This quantity tightly inclosed with the corn will prevent damage from those insects and will not injure the seed.

The material will cost about 10 cents a pound. One dollar's worth will protect seed enough to plant 60 acres.

TESTING THE GERMINATION OF SEED CORN.

Seed corn that matured normally and has been properly preserved will grow satisfactorily. It is very poor management to neglect proper preservation and to spend time in the spring separating by germination tests those ears that have been badly damaged from those that have been slightly damaged. Prevention is better than cure, and in this case a cure is impossible.

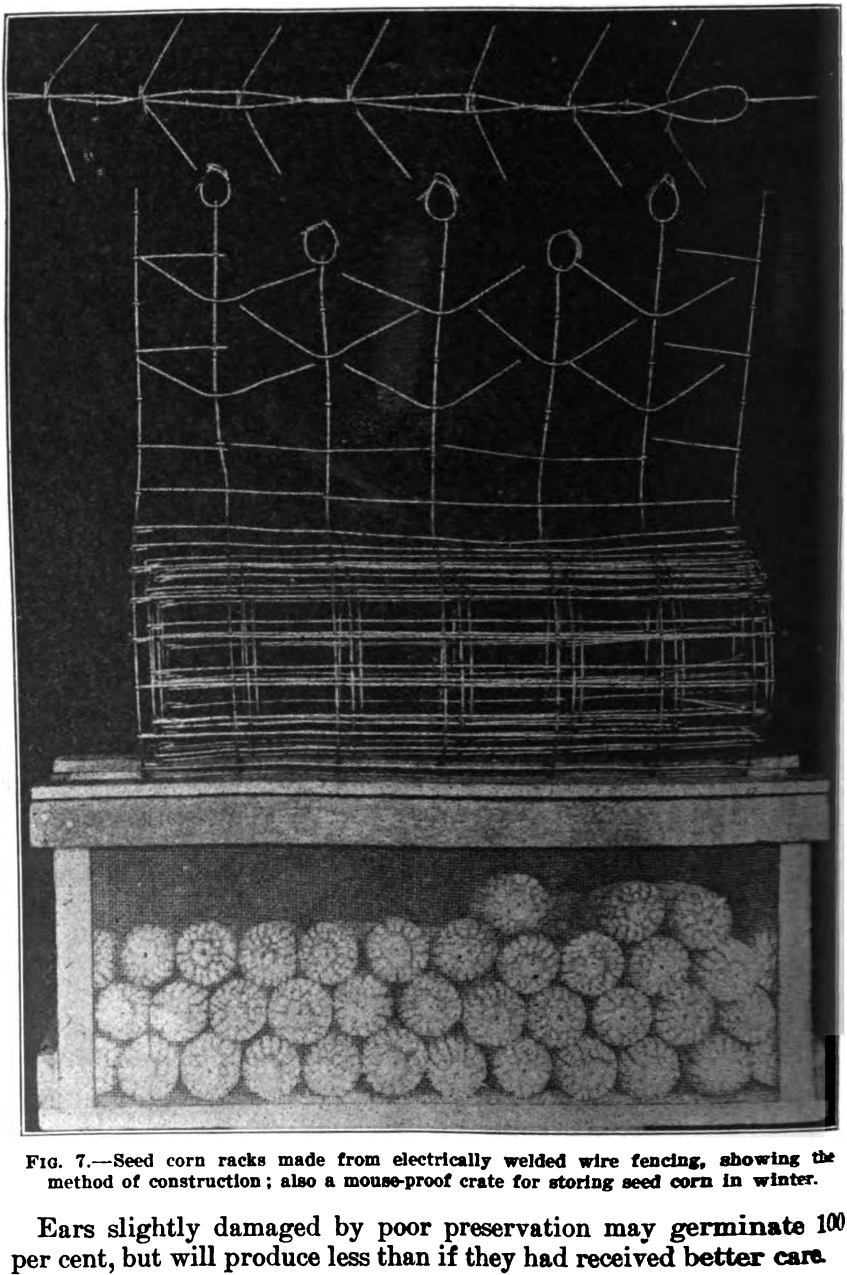

FIG. 7.—Seed corn racks made from electrically welded wire fencing, showing the method of construction; also a mouse-proof crate for storing seed corn in winter.

Ears slightly damaged by poor preservation may germinate 100 per cent, but will produce less than if they had received better care.

Make a seed-corn testing box or rag-doll tester and test 100 ears separately. Be sure that each kernel tested is perfect in appearance and was not injured at the tip when removed from the ear. If three or more kernels out of ten from any ear fail to grow it will be advisable to test every ear before planting. If the seed has been properly selected and preserved, the 100 ears tested will seldom reveal any poor ones, and further testing of the supply will be unnecessary.[3]

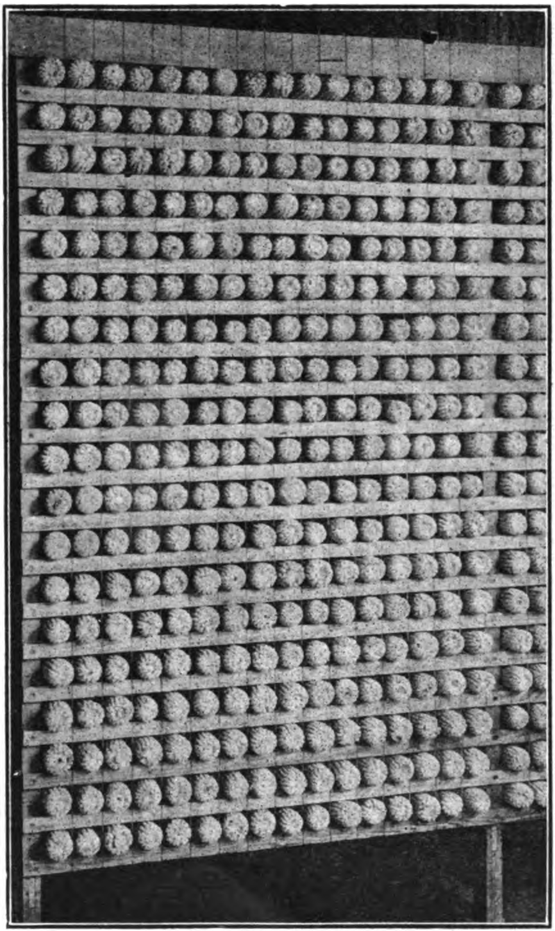

FIG. 8.—A good rack for drying seed corn.

GRADING SEED CORN.

Shelled corn is difficult to grade satisfactorily. The grading can be done better before the ears are shelled. If the seed ears vary greatly in size of kernels, they should be separated into two grades. These grades should be shelled separately, tried in the corn planter, and numbered to correspond with the number on the planter plates found to drop them most uniformly. These arrangements can be completed before the rush of spring work begins. The kernels of varieties of corn differ widely in size and shape, as shown in figure 9.

METHODS OF SHELLING.

SEED EARS SHOULD FIRST BE NUBBED.

The first operation in properly shelling seed corn is the removal of the small kernels from the tips of the ears and the round, thick kernels from the butts. The small tip kernels are less productive than the other kernels of the ear. The round butt kernels are as productive as the other kernels of the ear, but do not drop uniformly in a planter.

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[3] Complete directions for testing seed corn are given in Farmers' Bulletin 948, entitled "The Rag-Doll Seed Tester."

HAND SHELLING IS THE BEST METHOD.

Shelling seed corn carefully by hand is profitable. The greater the acreage planted, the greater the profit. Each ear should be shelled separately into a sieve,[4] rejecting any worm-eaten or blemished kernels. If the supply from the one ear appears good and contains no poor kernels, it is poured into the general supply and another ear is shelled in the same way.

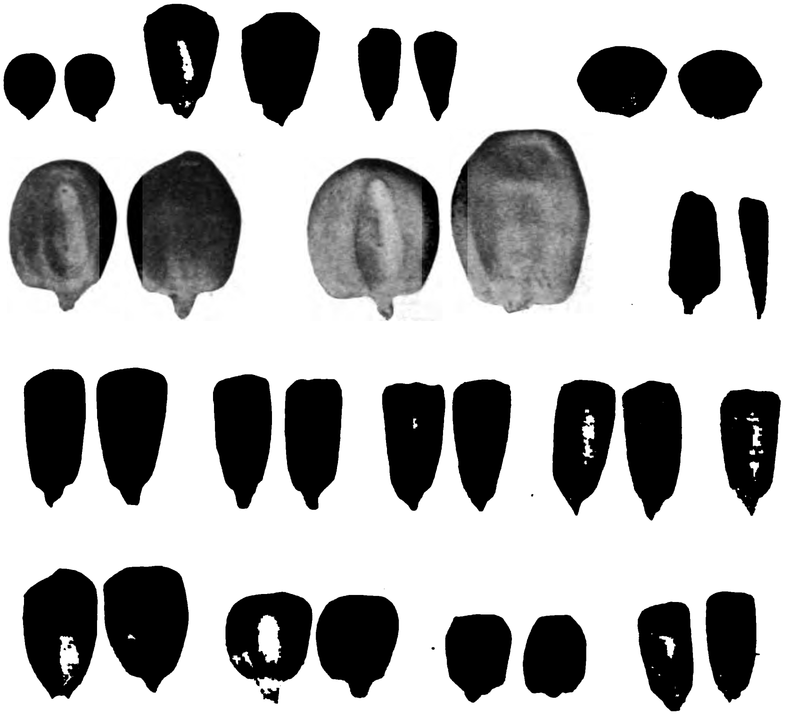

FIG. 9.—Corn kernels vary widely in size and shape. Some of the variations are shown here. Upper row (left to right), two kernels each of Pearl pop corn and Stowell Evergreen, Country Gentleman, and Black Mexican sweet corn. Second row, two yellow and two white kernels of Cuzco corn from Peru. The remaining kernels in this row and those in the third and fourth rows show variations in size and shape of kernels common to most corn-belt varieties. Uniformity in size and shape facilitates accurate machine planting. Equally good varieties may have kernels totally different in size and shape.

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[4] A large sieve with quarter-inch mesh and a concave bottom screens the chaff from the kernels and is easily emptied.

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